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# Monetary policy, credibility and central bank constitutions

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*To my parents*

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# Declaration Form

Chapter 3 is adopted from the joint paper with Marcus Miller, titled ‘Los peligros de delegar la política monetaria’ and published in *Información Comercial Española* No. 727, March 1994.

No other materials in this thesis have been published in any form.

# Abstract

Although most macroeconomists agree that the control of inflation may involve losses of output, there is no consensus about why.

New Classical economists, focusing on the issue of credibility, have identified incentive problems as important obstacles to price stability. On the contrary, many new Keynesians regard credibility problems as secondary. They focus on the microeconomic details of wage and price adjustments as potential sources of disinflationary costs.

Yet, if the costs and the benefits of anti-inflationary policy are strictly related to the market structure of the economy, so will be the incentives tempting the monetary authority to inflate. Indeed, what we show in this thesis is that the microeconomic aspects of wage and price setting not only affect the costs (benefits) of credible disinflationary (inflationary) policy, but that they need to be considered to determine whether those disinflationary (inflationary) policies can be perceived as credible or not.

Despite the relevance of this problem, the economic analysis of microfoundations has received little attention at the time of designing efficient resolutions for the credibility problem of monetary policy. This idea has been illustrated in different ways.

First, Rogoff's idea of delegation does not seem very attractive, if the wage setting process appears to be dominated by *insider* workers. Moreover, we have underlined the difficulties that a country like Spain, with a highly distorted labour market, may face in fighting inflation.

Second, interesting patterns of inflation and output behaviour may be generated by the interaction of both credibility problems and staggered wage setting.

Finally, although the difficulties of implementing anti-inflationary policies are emphasised in all our examples, they are particularly severe when near-rational behaviour or, alternatively, costs of changing prices are taken into account.



# Chapter 1

## Introduction

“One need not read far in the economic literature to learn that inflation is ultimately a monetary phenomenon. That is, it is not easy to conceive of the conditions under which inflation could continue at a high level or could accelerate for sustained periods unless that money supply also grew or accelerated. The most vigorous statement of this position comes from monetarist economists. Some have seemed to believe that the solution to the problem of inflation is rather simple – instruct the monetary authority to control the money supply. From that point of view, monetary authorities appear to be perverse or ignorant – else why haven’t they done the right thing already? A more sophisticated approach recognises that the reasons for the behaviour of the monetary authority are not so obvious.”

(*Wooley (1985).*)

Today most macroeconomists agree that the control of inflation can be costly in terms of output. Still, there is no consensus about why.

New classical economists argue that credibility problems are central to this complication, and they have identified incentive problems as important obstacles to price stability. If the public does not believe policy announcements for price stability, anti-inflationary policy will lead the economy into recession. In this fashion complicated formulae for central bank constitutions have been proposed in order to create the optimal incentives for the central banker not to inflate.

On the contrary, many new Keynesians regard credibility problems as less important. They have recognised the microeconomic details of wage and price adjustments as potential sources of disinflationary costs. If, for example, nominal rigidities were important, the persistence of high (or low) inflation might be seen as a consequence of the partial adjustment of underlying wages and prices to new information about the state of the economy. In the same way, the short-run costs (benefits) of disinflationary (inflationary) policy would depend upon the frictions and distortions that characterised the structure of the labour and goods markets.

Yet, if the costs and the benefits of anti-inflationary policy are strictly related to the market structure of the economy, so will be the incentives tempting the monetary authority to inflate. Therefore, credibility problems and wage – and price – setting



microfoundations cannot be easily separated when explaining the costs of disinflationary policy.

As an example, the departure from full rational behaviour or, alternatively, costs of changing prices have been held responsible for macroeconomic fluctuations in Akerlof and Yellen (1985). This paper is, no doubt, one of the most salient expositions of the new Keynesian tradition: changes in business activity can be generated by anticipated money supply changes, provided that some agents are willing to engage in near-rational behaviour. Credibility issues are not considered because the authors want to show that, even with perfect credibility, disinflationary policies might be costly. What we study in this thesis is how the microfoundations of near-rational behaviour affect the credibility problem of a monetary authority trying to control inflation. Rather than assuming perfect credibility, we show that the microeconomic details of wage and price setting have an extraordinary impact on the credibility problem suffered by the monetary authority.

Although this analysis is worth doing regardless of whether the economy is subjected to adverse shocks, it acquires special significance in the presence of supply-side disturbances. For example, Taylor (1980) demonstrates that, under staggered wage contracts, one-time shocks to the economy are capable of generating the type of unemployment persistence that has been observed during postwar business cycles in the United States. Moreover, the unemployment persistence of most European countries

could have been partly generated by one-time shocks, if the wage setting process was dominated by *insiders*, as in Blanchard and Summers (1988). In the presence of adverse supply shocks, the costs of anti-inflationary policies will depend upon the structure of the labour market. Yet, for the same reasons, such a market structure will determine whether the benefits of a one-time monetary surprise are more or less persistent.

Disregarding this problem and following the regulations governing the Maastricht Treaty, most European countries have revised their central banks constitutions in recent years or are in the course of doing so. For countries trying to build a reputation for fighting inflation, central banks have been guided towards the main objective of price stability. This has been so even for countries like Spain, which suffers from a highly distorted labour market structure.

Those who emphasise the preferences of the policy-maker and the role of tough policies, as an infallible method of signalling toughness and raising credibility, do not seem to consider the market structure of the economy, although such a structure is at the core of the output costs caused by a disinflation.

The role of external circumstances was clearly illustrated with the breakdown of the European Monetary System (EMS), on August 1st, 1993. With unemployment persistence, avoiding realignments to signal the toughness of governments proved too



costly. Policy-makers could not ignore pressures to restore high employment and the financial markets correctly anticipated the devaluation of the Spanish peseta, the Sterling pound and the Italian lira. Alternatively, France had to apply large interest differentials in order to control devaluation expectations. What this implies is that the credibility problem reflects not only the policy-maker's intention but also the state of the economy.

Furthermore, as suggested by Ball (1995), building a reputation for fighting inflation will be very costly with unemployment persistence, if the public is not certain about the type of the policy-maker, i.e., if there is a credibility problem. Accommodative monetary policy may put the reputation of the central bank at risk, if the public identifies the accommodation of the shock with a relaxation of monetary policy.

This thesis represents an attempt to combine two elements: credibility problems and market structure of the economy. Chapter 2 describes the difficulties found on the way to European Monetary union (EMU). It also introduces the literature on the time consistency problem of monetary policy and the institutional arrangements which will characterise the European System of Central Banks (ESCB). Chapter 3 considers two important issues for European Monetary Integration: the asymmetry of policy making in Europe and the persistence of unemployment in European labour markets. The Spanish experience and the difficulties of the Spanish authorities for controlling inflation, without further pressures on unemployment, receive special attention in

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Chapter 4. Chapter 5 presents different patterns of inflation and output behaviour generated by the interaction of both credibility problems and staggered wage setting. Finally, the severe difficulties of implementing anti-inflationary policy are emphasised in Chapter 6, where near-rational behaviour or, alternatively, costs of changing prices have been taken into account. Chapter 7 concludes.

## Chapter 2

# The European Central Bank and the debate on delegation

### 2.1 Introduction

The economic analysis of monetary policy has been dramatically reorientated after the rise of the time consistency literature. The main principle suggests that if, for example, the monetary authority is known to be concerned over output and employment, it will have difficulties convincing the public of its well-meaning behaviour for controlling inflation.

Although there is no academic consensus about how to tackle this problem, central bank independence has emerged as a tool that might reduce this complication.



In recent years we have witnessed an extensive number of reforms in central bank legislation. Since the end of the 1980's, not only the European countries immersed in the regulations governing the Maastricht Treaty, but also the countries outside the European integration process, such as New Zealand, Chile or Argentina, have revised their central bank constitutions, granting them more authority and guiding them towards the main objective of price stability.

These proceedings, based upon the exemplary inflation record of the Bundesbank and upon the theoretical analysis of Rogoff (1985a), have stimulated a vigorous controversy. The reason is that, in theory, the central banker's anti-inflationary bias, which controls expected inflation, tends to increase the variance of output and employment in the presence of supply-side shocks.

In this chapter we describe in some detail two particular aspects of this dispute. Section 2.2 presents the proposed stages and the difficulties found along the way to European Monetary Union (EMU). Section 2.3 outlines the institutional arrangements, which will characterise the European System of Central Banks (ESCB), and the controversy on whether these proceedings are the right mechanism to overcome the so-called time consistency problem of optimal monetary policy. Section 2.4 concludes.



## 2.2 European Monetary Integration

### 2.2.1 The blueprint

The European Community (EC) has been aiming to achieve an economic and monetary union since 1969.<sup>1</sup> In the years after the signing of the Treaty of Rome (1957), the main achievements of the EC were the completion of the customs union and the establishment of the Common Agricultural Policy (CAP). The Treaty, however, had no provisions for monetary arrangements, mainly because the currencies of the six initial member states were part of the international monetary system of fixed exchange rates negotiated at Bretton Woods. Moreover, the stabilisation of exchange rates in the early 1960's did not imply the sacrifice of domestic targets; inflation and unemployment were low enough so that fiscal and monetary policies were conducted smoothly, and the still rudimentary capital markets gave the monetary authorities some scope to correct domestic disequilibria.

In 1969, acknowledging that closer coordination of economic and monetary policies was necessary, the Heads of State or Government of the six initial member states – The European Council – expressed their wish to see the Community develop into an economic and monetary union through the implementation of a phased plan. A group of experts chaired by Pierre Werner, then Prime Minister of Luxembourg, prepared

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<sup>1</sup>For a description of European monetary integration, see Gros and Thygesen (1992).

the so-called Werner Plan, which was endorsed in 1971. An agreement on narrowing margins of fluctuation of the Community currencies, termed *the snake*, was reached. Furthermore, the European Monetary Cooperation Fund (EMCF) was established as the intended forerunner of a Community system of central banks. At that time, the process of monetary integration was questioned because countries could not agree on policies in response to the main shocks of the period: the oil crisis and the collapse of the Bretton Woods monetary system.

A major initiative to relaunch monetary integration was not established until 1979, when the European Monetary System (EMS), a system of stable but adjustable exchange rates, was set up. In its origin, the EMS, a political rather than economic initiative, was believed to be as unstable as *the snake*. However, after a turbulent start, realignments became less frequent and inflation differentials returned to the range known during the 1960's.

The perceived success of the EMS, during the first ten years of its existence, contributed to further progress in European integration.<sup>2</sup> As a result, the Single European Act, the first major revision of the Treaty of Rome, was signed in 1986. It reaffirmed old objectives and established additional ones, such as the achievement of the single market, the strengthening of economic and social cohesion, and the gradual

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<sup>2</sup>See, for example, Giavazzi and Pagano (1988) for an analysis of the effective disciplinary device of the EMS.



realization of EMU. The concrete stages leading towards EMU were finally endorsed in the so-called Delors Committee Report, which was presented in April 1989.

The Report proposed three stages:

**Stage One** involved the completion of the single market, closer co-ordination and harmonisation of economic and monetary policy, and the negotiation and ratification of the Treaty amendments needed to establish EMU.

**Stage Two** included the implementation of the new Treaty and was conceived as a transition period for the new institutional arrangement. It involves the strengthening of co-ordination procedures based on multilateral surveillance, so that member states enter into reciprocal commitments needed to ensure financial stability, credibility, and final success of EMU. Furthermore, the European System of Central Banks (ESCB) has now been established.

**Stage Three** will consist of the irrevocable fixing of exchange rates and the transfer of powers for administering economic and monetary union.

In December 1989, EC Governments convened an Inter Governmental Conference to prepare the changes in the Treaty of Rome required for the creation of a Central Bank. This Conference concluded a blueprint revision of the Treaty of Rome by December 1991, *The Maastricht Treaty*. Although the new Treaty was signed by all

Community members' Heads of State or Governments at that time, it needed to be ratified within individual countries. According to the Treaty, countries willing to join the single currency area – in Stage Three – should achieve the following controversial set of convergence criteria:<sup>3</sup>

- (i) A consumer price inflation rate no more than 1.5 percentage points above the average for the three countries with the lowest inflation rates,
- (ii) average nominal long-term interest rates no more than 2 percentage points above those for the three countries with the lowest inflation rates,
- (iii) non-realignment of national currencies within narrow bands in the EMS, for at least two years before the irrevocable locking of exchange rates, and
- (iv) a sustainable government financial position, defined as a general government deficit to GDP ratio of less than 3 per cent, and a gross debt to GDP ratio of less than 60 per cent. Although these are the numbers that dominate the public discussion, the Treaty contains important qualifications for the budgetary discipline of the Member States. With respect to the issue of debt the final decision will take into account the following criteria:

- (a) first, whether the ratio of the planned or actual government deficit to gross domestic product exceeds a reference value, unless either the ratio has

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<sup>3</sup>See, for example, Hughes Hallet and McAdam (1996) for an analysis of the consequences and importance of attempting to impose those criteria.



declined substantially and continuously and reached a level that comes close to the reference value, or, alternatively, unless the excess over the reference value is only exceptional and temporary and the ratio remains close to the reference value;

- (b) second, whether the ratio of government debt to gross domestic product exceeds a reference value, unless the ratio is sufficiently diminishing and approaching the reference value at a satisfactory pace.

At Maastricht, it was also agreed that, at the end of 1996, the European Council would have to vote, by qualified majority, on whether a majority of member countries satisfies the convergence criteria above, basing their decisions on a report to be given by the Council of Economic and Finance Ministers. The Council would then decide the suitability for progressing to stage three of EMU. On the other hand, if the Council found it inappropriate to move forward, Stage Three would start on January 1st, 1999. In fact, the Madrid meeting of the European Council reaffirmed, in December 1995, the commitment of the European Union's leaders to Monetary Union by January 1st, 1999.<sup>4</sup> Those countries that had not satisfied the criteria would enjoy a special status, *Members States with a derogation*, and their situation would be periodically reviewed.

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<sup>4</sup>See Gros (1996) for an extensive report on the most recent developments in the way towards EMU.

### 2.2.2 In reality...

In a number of European countries, under the auspices of the EMS, monetary policy was entirely directed at stabilising exchange rates. This strategy, named *competitive disinflation* by Fitoussi *et al.* (1993), seemed infallible: in a fixed exchange rate regime, a country with higher inflation than its trading partners loses competitiveness; as a result, aggregate demand falls and unemployment goes up. Subsequently, with high unemployment and lower competitiveness, inflation decreases over time. Finally, in the long-run, improved competitiveness leads to lower unemployment. The strategy is *virtuous*: it not only delivers low inflation and a strong currency, but also full employment and renewed competitiveness.

The breakdown of the Exchange Rate Mechanism (ERM) of the European Monetary System at the beginning of September 1992 demonstrated how difficult it is to carry through the project of EMU. Following the exceptional circumstances which started with German re-unification, the *virtuous* approach proved too costly. The need for high German interest rates to contain domestic inflation involved a massive real shock to the system and unemployment rates returned to levels unknown since the 1930's.

At that time, a Deutschmark (DM) real appreciation was advocated by Begg *et al.* (1990):<sup>5</sup>

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<sup>5</sup>The Bundesbank had long believed that both the lira and the sterling were overvalued. See Marsh (1992).



“The real DM must initially appreciate but then decline to a level lower than its initial position, real interest rates in Germany must exceed those elsewhere ... The question is whether other EMS countries should match the initial DM appreciation ... we believe the answer is no ... The impact of these changes is large immediate ... but the position will then unwind over a decade or more ... The case for an immediate DM realignment is overwhelming.”

The same authors also argued that, even in the absence of German re-unification, the opening of Eastern Europe economies would have led to a DM realignment against its EMS partners. Quite simply, the reason was that the former West Germany would have attracted a disproportionate share of demand from the East.<sup>6</sup> Indeed, unsustainable high interest rates forced Britain and Italy to leave the ERM. Furthermore, the Spanish peseta and the Portuguese escudo had to be devaluated; Denmark, France and Ireland saw their currencies seriously threatened; Finland, Norway and Sweden had to remove their unilateral pegs to the ERM.

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<sup>6</sup>The greatest evidence of the professional consensus on the fragility of the system is probably supplied by Portes (1993).

Table 2.1: Convergence Criteria – European Community.

|                | Inflation | Interest rates | Govt. net borrowing (*) | Public Debt (*) |
|----------------|-----------|----------------|-------------------------|-----------------|
| Objectives     | 3.0       | 10.4           | 3.0                     | 60.0            |
| EC 15          | 3.0       | 8.1            | 3.1↓                    | 71.3↓           |
| Belgium        | 1.6       | 7.9            | 3.5↑                    | 130.0↓          |
| Denmark        | 2.2       | 8.6            | 0.5↓                    | 70.5↓           |
| Germany        | 2.2       | 7.1            | 2.4↓                    | 59.3↓           |
| Greece         | 9.9       | 18.4           | 7.3↓                    | 113.1↓          |
| Spain          | 4.7       | 11.5           | 3.6↓                    | 65.4↓           |
| France         | 1.7       | 7.8            | 2.9↓                    | 54.2↑           |
| Ireland        | 2.6       | 8.5            | 1.3↓                    | 76.9↓           |
| Italy          | 4.7       | 12.3           | 5.2↓                    | 122.3↓          |
| Luxembourg     | 2.1       | 6.2            | - 0.7↓                  | 6.8↑            |
| Holland        | 2.2       | 7.2            | 2.7↓                    | 77.8↓           |
| Portugal       | 4.2       | 11.7           | 4.7↓                    | 70.9↓           |
| United Kingdom | 3.3       | 8.4            | 3.7↓                    | 53.2↓           |
| Austria        | 2.5       | 7.3            | 5.0↓                    | 71.5↑           |
| Sweden         | 2.6       | 10.7           | 4.5↓                    | 79.8↓           |
| Finland        | 1.3       | 9.4            | 1.5↓                    | 64.5↓           |

Source: Banco Central Hispano, November 24th, 1995

Inflation: Private consumption deflator.

Govt. net borrowing: In % of GDP.

(\*) Forecast 1997, ↑ Trend upwards, ↓ Trend downwards.

After a year of turmoil in the EMS, the currency crisis was brought to an end only when the EMS was radically reformed and loosened its rules. On August 1st, 1993, the currencies that remained in the system were allowed to fluctuate by  $\pm 15\%$  from their central parities, in contrast with the previous limit of  $\pm 2.25\%$ . For many months the breadth of the fluctuation bands brought relative tranquility to the EMS. But the spectre of a new crisis was raised when, in an apparent consequence of the



Mexican crisis, the peseta and the escudo suffered from a devaluation on March 7th, 1995.

Since then, after a period of introspection, Europe's federal illusions have followed a different path. Politicians seem to talk about *widening* the Community, rather than *deepening* it. In fact, Austria, Finland and Sweden, countries which have negotiated their integration into the EMU recently, present a relative advantage with respect to other countries of the EC. The securing of a majority of countries (nine out of fifteen), which satisfied the convergence criteria described above, might be facilitated by the incorporation of these three countries. Such an event would necessarily mean a *second speed* for those countries less favourably placed.

Although it is unclear what is going to happen on January 1st, 1999<sup>7</sup>, most European countries, when making decisions on monetary and fiscal policy, give top priority to their qualification for EMU. From an economic perspective, such a qualification, as described in the convergence criteria above, will be based mainly on *nominal* principles. The achievement of low inflation, low long-term interest rates, and the pursuit of sound fiscal policy are now at the top of the political agenda, despite high levels of European unemployment. This reflects the discomfort of an alleged credibility problem, suffered by most European countries and which might complicate the German

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<sup>7</sup>While the attainment of the convergence criteria remains to be seen, so does the political willingness to move towards Stage Three of EMU.

decision on surrendering the very reliable Deutschmark.

If the opening of Stage Three of EMU effectively implies the transfer of monetary policy to a supra-national institution, it is easy to envisage the German concern over the delegation of monetary policy to an institution other than the Bundesbank. Yet, which are the features making the Bundesbank the most envied European central bank? Why should central banks across Europe and, in particular, the ESCB try to duplicate the institutional design of their German counterpart? We turn to this issue in the next section.

## 2.3 The ESCB

### 2.3.1 The ESCB's solution to the time consistency problem

Kydland and Prescott's (1977) seminal work, showing that optimal macroeconomic policies could be dynamically inconsistent, has resulted in the reorientation of monetary policy analysis. Incentive problems have been recognised as important obstacles to price stability; efforts intending to *depoliticise* monetary authorities have been seriously undertaken.

The basic premise is that monetary policy-making can be viewed as an agency problem between society and the monetary authority. The public interest is to achieve



low inflation and to stabilise output and employment around certain socially desired levels. It is then assumed that, because of special characteristics of the labour market, the monetary authority has the incentive to affect the real economic activity in the short-run. Hence, controlling inflation is not a credible policy, if the government is known to care about output.<sup>8</sup> But rational expectations affect price dynamics, because prices cannot fully and instantaneously react to current information. Governments who wish only to stop inflation cannot easily persuade the public of this fact, and therefore induce severe protracted recessions when they try it.

The possibility that the government might establish a reputation for fighting against inflation in an infinitely repeated game has been explored by Barro and Gordon (1983). The central feature of the model is the *punishment* strategy implemented by the private sector once the government has deviated from the socially optimal equilibrium. However, this strategy is arbitrary and there will be multiple Nash equilibria depending on the form in which this *punishment* is actually implemented.

Backus and Driffill (1985) examine a case for uncertainty, where the public does not know which type of government behaviour it faces, i.e., whether or not the government is committed to pursuing a zero inflation policy. In this case, applying the concept of sequentially rational equilibria, given a sufficiently long time horizon and a

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<sup>8</sup>Incentives to inflate may arise from revenue motives, financial stability considerations or directly from the nature of monetary institutions.

non-zero initial reputation for fighting against inflation, there might be an equilibrium with zero inflation.

Although both of these concepts of reputation have been criticised<sup>9</sup>, they capture interesting elements of what reputation means in practice. Barro and Gordon (1983) capture the idea that a central bank, whose preferences are well-known, can improve social welfare, in an infinitely repeated game, by acting in its long-term interest. Backus and Driffill (1985), however, assume that the central bank's preferences are unknown and show how proper behaviour can engender a favourable reputation. This last work is particularly relevant to European countries and to the composition of the ESCB, for it incorporates the *prior belief* notion representing the central bank's initial reputation.

Although there is no single panacea for price instability, central bank independence has emerged as a factor which itself improves monetary behaviour. An institution which is fundamentally free from political constraints would not make opportunistic use of monetary policy, and it would enjoy the credibility that the policy-maker lacks. In this sense, stylised institutional design tending to grant partial independence to a *conservative* central banker, who places a higher weight on inflation than the policy-maker, has been suggested by Rogoff (1985a). This paper (mainly written when

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<sup>9</sup>Punishing strategies are an equilibrium only when all members of the public choose to follow them. These strategies, therefore, require some degree of coordination among the members of the public. Conceiving of a mechanism that would bring people together is, however, difficult.



its author was working for the Board of Governors of the Federal Reserve of the USA) explains the value of delegating policy to an agency, known to be more anti-inflationary than the government itself, as a credible method of reducing expected inflation.<sup>10</sup>

Rogoff, however, is careful to qualify the point in several important respects. He observes, for example, that unqualified delegation is inferior to *first-best* policies aimed at eliminating the distortions tempting monetary policy makers to inflate; and that it is also inferior to *second-best* policies consisting of appropriate innovation-contingent feedback rules.<sup>11</sup> Indeed, Rogoff notes that the anti-inflationary bias, which checks expected inflation, has a tendency to raise the variance of output and employment in the face of supply shocks, such as a rise in the price of imported oil. Choosing the ideal central banker, therefore, involves balancing gains on the anti-inflationary front against losses of flexibility in handling such supply-side shocks.

When supply-side shocks are considered, however, given that the policy-maker would like to retain the flexibility to employ monetary instruments to stabilise employment and output, a dominating institution would be such that the policy-maker retains the option to override the central bank's decision. In this way a non-linear policy rule could be implemented so that for large shocks to output, the central

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<sup>10</sup>See Cukierman (1992) for an extensive study on the value of delegation.

<sup>11</sup>There are no standard reasons to explain why such state contingent rules cannot be enforced, but it is generally agreed that the difficulty to observe the realization of shocks, and the problems of specifying a complete range of rules to follow under all contingencies, make such rules infeasible.

bank would accommodate the policy demands. This conclusion has been reached by Lohmann (1992), who discusses the idea of qualified delegation, where the authorities can (at a cost) override the central bank. This is the case with the Netherlands Bank. As described in *The Economist* (1990), the Bank conducts its own monetary policy in normal circumstances. But, if the Dutch Government exercises its overriding power and the Bank objects, the Bank's case as well as the Government's need to be published. The prospect of a parliamentary motion of no confidence, that will force either the Government or the Central Bank's Governor to resign, has prevented this happening.

More flexible institutional arrangement than the simpler unqualified delegation to an anti-inflationary central bank has been also proposed by Flood and Isard (1989). These authors analyse the implementation of simple rules with escape-clauses where supply shocks turn out to be large. However, in all of these cases, a trade-off between credibility and flexibility still remains. If the central bank cannot optimally offset adverse supply shocks, delegation to a conservative central banker can only be proposed as a *third-best* policy.

A more promising way of creating the optimal incentives for the central banker, by choosing a central banker with *perverse* preferences, has been suggested in Persson and Tabellini (1990). In particular, the ideal output – alternatively, employment – targeting regime, which eliminated the output distortions tempting the monetary



authority to inflate, would solve the credibility problem of the optimal monetary policy.

The role of private information in monetary policy games was first studied in Canzoneri (1985). Without private information, resolutions of the credibility problem would be too easy to come by. In the absence of central bank private information, the public can always tell when the monetary institution has been honest or what the policy-maker's true preferences are, so that these monetary games cannot be regarded as a serious universal problem. Besides, these models do not help to explain the episodic periods of *credibility breakdowns* and bouts of inflation that are actually observed. As pointed out in Canzoneri (1985), the credibility problem of the monetary institution is a *real* problem only in the presence of private information. If the central banker's adherence to the ideal policy rule cannot be verified directly, efficient resolutions of the credibility problem will be much more difficult to find.

Fратиanni and Huang (1995), based on a synthesis of Canzoneri (1985) and Rogoff (1985a), demonstrate that reputation alone cannot solve the time inconsistency problem of monetary policy. Most importantly, they show that, in an environment of private information, reputation can substitute for conservativeness. This result has special significance. Central banks with a good reputation, such as the Bundesbank, can afford to be less conservative than central banks with a worse reputation. Therefore, the central bank gains from extra flexibility in output stabilisation. A similar

argument can be found in Lockwood *et al.* (1995). Based upon reputational building factors *à la* Barro and Gordon (1983), they consider delegation to a central bank that is both more far-sighted and more conservative than the government. Even without asymmetric information, extending Rogoff's model to take account of reputation could improve social welfare if the central bank has incentives for building a reputation against inflation. Although the central bank cannot achieve the government's precommitment rule, it still pays the government to *free ride* on the central bank's superior ability to maintain a reputation. Once again, society gains from extra flexibility in output stabilisation, as delegation to far-sighted central banks is a substitute for Rogoff's delegation to a conservative central banker.

Agenda theory and contractual design have been used by Persson and Tabellini (1993), Fratianni *et al.* (1993) and Walsh (1995) to obtain a solution to this problem that eliminates the inflationary bias of discretionary policy, while still ensuring that inflation responds optimally to aggregate supply shocks. In standard monetary policy games, where the inflationary bias is constant across states of nature, an incentive contract that internalises the cost of higher expected inflation – thus, raising the marginal cost of inflation – could deliver the optimal state-contingent policy. Although the feasibility of implementing any incentive contract is discussed in depth – the most obvious problem being that they are not *renegotiation proof* –, these authors have suggested the following: (a) making the central bank's budget or the income of the central



bank Governor contingent on the state of the economy, and (b) a dismissal threat, if inflation exceeds a critical value. This is the case of the New Zealand Reserve Bank Act of 1989, which includes publicly announced conditions under which the central banker may be fired. But, as pointed out in Lockwood *et al.* (1995), governments do not hire central bank Governors on performance contracts of the type required by the theory. In fact, performance contracts, such as New Zealand's, bear little resemblance to those suggested in the literature.<sup>12</sup>

An additional difficulty arises in models where the optimal incentive contract is state-contingent. For instance, in models with output persistence, the incentive contract approach clearly shifts the problem for designing central bank rules that capture a complete range of states of nature to writing an incentive contract with, for example, an equally large number of incomes for the central bank Governor. Since there is no reason why the latter should be easier to establish, Herrendorf (1995) has suggested a combined solution of delegation to a conservative central bank with a feasible, optimal designed contract as a powerful mechanism to overcome the credibility problem in these cases.

Finally, the most recent proposal to pick up the ideal central banker's preferences can be found in Svensson (1995). An *inflation target* conservative central bank, with an inflation target equal to the difference between the socially desired inflation rate

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<sup>12</sup>See Fischer (1995) for a description of the New Zealand's experience.

and the inflationary bias, dominates the Rogoff's *weight conservative* central banker and delivers the precommitment outcome, in a model without output/employment persistence. However, in the presence of persistence, a combination of an optimal state contingent inflation target and a weight conservative central bank is required to achieve the *second-best* solution. In a parallel study, the need to combine inflation target regimes or inflation contracts with the appointment of a Rogoff-type conservative central bank has been also advocated by Muscatelli (1996). In the presence of uncertainty about the central bank's preferences, a combination of both inflation contracts (alternatively, inflation targets) and a weight conservative central banker, though inferior to *second-best* policies, will be desirable.

Solving the time inconsistency problem of monetary policy becomes, somehow, more controversial if, as in Herrendorf and Lockwood (1996), we allow for private information on the side of wage setters. If the delegation decision of the government cannot be made state-contingent on the private information of wage setters, a combination of an appropriate choice of either employment/output targets or a linear inflation contract and a weight conservative central banker is optimal. Although the government can no longer achieve the optimal precommitment rule, supplementing weight conservatism with alternative ways of choosing optimal preferences dominates Rogoff's suggestion of appointing only a weight conservative central banker.

In summary, private information and output persistence should be viewed as tech-



nological constraints at the time of designing efficient resolutions of the credibility problem. It is most likely that the delivery of optimal monetary policy, which controls expected inflation but allows for optimal output stabilisation, is not uniquely determined. It also appears to combine several of the alternative delegation instruments suggested in the literature. The resolution of the credibility problem is, therefore, a matter that deserves further attention.

In particular, the empirical work on central bank independence should be carefully revised. There is a consensus in the empirical literature on central bank independence, that Rogoff's caveat on delegation does not hold.<sup>13</sup> In other words, while central bank independence reduces the level and the variability of inflation, it does not have any impact on real economic performance. This observation suggests that the inflation benefits of central bank independence are likely to outweigh the output and employment losses. But independence is not the same as conservativeness. The literature referred to above suggests that reputation for fighting inflation, such as the Bundesbank's, is a substitute for conservativeness. Furthermore, linear inflation contracts or, alternatively, inflation/output targets can complement the central bank's weight conservativeness, so as to allow for more output stabilisation. Hence, if distinguishable delegation instruments deliver different outcomes, it is imperative that the empirical literature also discriminates among them.

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<sup>13</sup>See, for example, Alesina and Summers (1993) and Cukierman (1994).

Moreover, goods and labour market structure across countries should be incorporated into the empirical work, in order to account for the dangers of delegation. Waller (1992) analyses how the heterogeneity of market structure affects the equilibrium inflation rates and the choice of a conservative central banker *à la* Rogoff. In our opinion, the latter problem has received very little attention.<sup>14</sup> Besides, with heterogeneity of market structure across Europe, countries will disagree on the optimal trade-off between output stability and inflation stability. Despite their importance, these matters were widely disregarded at the time of designing the institutional arrangements for the ESCB. The ESCB's statutory provisions are the issue to which we turn in the next section.

### 2.3.2 The ESCB's statutes

A single currency implies a single monetary policy. In this sense, the creation of a monetary institution, to which countries delegate monetary policy, constitutes one of the most polemical tasks in the process of European integration.

The monetary authority conceived for the EMU is the European System of Central Banks (ESCB). The ESCB is composed of a European Central Bank (ECB) and of national central banks, and the governing bodies are the Governing Council and the

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<sup>14</sup>In the following chapters, we consider some of the special characteristics of market structure, so as to analyse their implications for the credibility problem.



Executive Board. The Executive Board, which includes the Governor of the ESCB and comprises six members, is appointed by the European Council. The Governors of the national central banks, chosen within individual countries, and the Executive Board constitute the Governing Council.

If it is true that, *Citizens need to be protected from their own Governments as much as from muggers and invading armies* (The Economist, February 10th, 1990.), the legal structure of the ESCB may be of great importance. In his *Reflections on the proposed statutes of the European Central Bank*, Alberto Giovannini (1993) has compared the proposed European System with those currently in the USA and Germany. From a literal interpretation of the statutes, he concludes:

“Given the limited political importance of the European parliament, and given its inability of affecting any of the regulations concerning the European System of Central Banks (ESCB), it appears that the ESCB formally enjoys more independence than the other two institutions. This impression is confirmed by the sheer number of articles that appear to be expressly devoted to guard it from political pressures emanating from national governments or any other entities.” (Giovannini, (1993), p. 11.)

Political independence implies that members of central bank Boards must be free from Government pressure when choosing monetary policy, i.e., the central banker

must be *goal independent*. Political independence is, therefore, intended to avoid the governmental decision in setting certain targets for the central banker, who is then penalized for non-attainment of these. To some extent, this concerns the procedures for appointing and dismissing Board members. The proposed statute of the ESCB designates an eight year term for the Governor and the other members of the Executive Board – the same as the Bundesbank. Governors of national central banks will be elected for a minimum term of five years, depending on national regulations. Such a long-term of office will help to impede sudden dismissals of the officials and, as the price stability objective is explicitly mentioned in the statutes, the ESCB is likely to enjoy a high degree of independence.

Economic independence refers to the ability of the ESCB to use optimal monetary instruments to achieve its monetary policy objectives. *Instrument independence* includes restrictions on financial government spending and on government's interference with daily policy-making. This reflects a general tendency to separate monetary and fiscal authorities.

One of the main weaknesses of the ESCB has been stressed by Goodfriend (1983), who has expressed concern over the excessive decentralisation in the Governing Council, the policy-making body of the ECB. Following the spirit of the Early Open Market Committee of the Federal Reserve, the highly decentralised Governing Council seems to be lacking in a preeminent personality able to provide coherent and decisive pol-



icy. This could affect the ECB's ability to deliver stable prices. National central bank Governors – regional representatives of national interest – could easily outvote the six Executive Board members, and national political pressures might produce a majority in favour of inflationary monetary policy. The incentives to pursue loose monetary policy might be reinforced by the potential revenue from seignorage and the well-known expansionary effects of monetary policy coordination.<sup>15</sup>

Finally, the fundamental disadvantage of independence, the costs in terms of accountability, needs to be resolved. The statutes of the ESCB specify the need for an annual report which subjects the central bank's activities to the scrutiny of European Parliament.

The planned structure of the ESCB doubtless owes more to the perceived lessons of historical experience than to the published papers of academics. As for where the proposed European statutes stand on the issue of rules *versus* discretion,

“it is widely believed that in this, as in many other aspects,... the [revised] Treaty of Rome [has] copied the Bundesbank Act. Rather than imposing on the bank a fixed rule, these statutes assign it an objective (albeit vaguely worded): safeguarding the currency and price stability. They then give it substantial independence in pursuing that single objective,

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<sup>15</sup>See Rogoff (1985b).



and subordinate all other activities to it” (Giovannini, (1993), p.11.)

Given that a central bank may be given a substantial degree of independence, the issue of how the delegated power should best be exercised is obviously of great importance. The provisions guaranteeing independence are certainly designed to allow a conservative central banker to operate efficiently. But, in Giovannini’s view, in some respects the statutes of the ESCB *outperform* Rogoff:

“By making the Central Bank independent, limiting its objective to price stability, and, more importantly, cutting linkages between monetary policy and the financing of budget deficits and, at the same time, providing procedures to stem the build up of large government debts, the revision of the Treaty of Rome could ... eliminate the incentives that monetary authorities have to systematically affect real economic activity beyond its natural rate” (Giovannini, (1992) p.15).

In Giovannini’s eyes, therefore, the provisions of the Maastricht Treaty may well have removed the inflationary bias from time consistent monetary policy, so the *second-best* outcome discussed above might be achieved. If this is true, however, then there is no need for any conservative bias. Monetary policy should be able to respond fully to temporary shocks without triggering expectations of persistent inflation.

But the Treaty also legislates for the objectives of policy and gives primacy to

price stability; indeed, the ordering of objectives appears to be lexicographic – other objectives can *only* be pursued once price stability has been achieved. No trade-off is permitted. Such a stern anti-inflationary bias is, as indicated, actually unnecessary, if the Treaty has really solved the incentive problem; and even if it has not, the bias seems excessive in the light of Rogoff's analysis.

## 2.4 Conclusions

After years of evident enthusiasm, the journey towards greater European monetary integration appears to have reached an impasse. Since the beginning of the 1990's the sensational increase in unemployment rates across European countries has divided the economic profession and the political class.

The supporters of the Maastricht orthodoxy have insisted that price stability and sound fiscal policy should be followed. These recommendations have been bitterly criticized by those economists who perceive the formidable European unemployment rates as frightening losses of human lives. For governments trying to build a reputation for fighting inflation, the sacrifice in terms of employment losses is believed to be worth paying in the long-run.

But countries across Europe may have to bear different losses when implementing anti-inflationary policies. The reason is that the heterogeneity of market structure

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across Europe seems to lead to different optimal feedback rules. Therefore, convincing the public about the government's well-meaning behaviour will prove very costly for countries like Spain, with a highly distorted market structure. According to the literature referred to above, further complications seem to arise also with imperfect information, as solutions to the time inconsistency problem imply a combination of parameters rather than a more simplistic notion of delegation. Finally, the delegation of monetary policy to a too conservative supra-national central bank has been subject of speculation. In this scenario, the debate over how the ESCB's delegated power should best be exercised has been heated, and the dispute continues.



## Chapter 3

# *Hysteresis*: The consequences of persistent unemployment

### 3.1 Introduction

This chapter considers two important issues for European Monetary Integration, which must be taken into account when one considers the merits of delegation. The first of these is the *asymmetry* of policy-making in Europe, and the second is the persistence of unemployment in European labour markets.

The asymmetry arises from the fact that monetary policy decisions in the EMS are effectively delegated to a national central bank, the Bundesbank, even though it has no constitutional obligations to concern itself with European matters. This exposes

the system to particular strains in the face of shocks not common to all members of the EMS, as shown in Section 3.2 of this chapter.

The serial correlation or persistence of unemployment has been described, for example, by Lockwood and Philippopoulos (1994). Section 3.3.1 presents a diagrammatic interpretation of how the persistence of unemployment will affect the sort of monetary policy which is appropriate in the face of supply-side shocks. The rest of the chapter is organized as follows: Section 3.3.2 describes the basic model; Section 3.3.3 shows that, as the benefits of accommodating supply-side shocks rise sharply with the high degree of *hysteresis* that characterises the European labour markets, rigidly anti-inflationary policy seems inappropriate; and Section 3.4 concludes.

## 3.2 Asymmetry of decision making in Europe

The case for delegating monetary policy is normally discussed in the context of a single country, where policy discretion passes from central government to an independent national agency. But in the context of the European debate, delegation has involved transferring policy discretion across national frontiers, since belonging to the ERM with narrow bands means *de facto* accepting monetary policy decisions made by the Bundesbank in pursuit of its own national objectives.

In this context, a key assumption of the Rogoff model – that there will be no



adverse effects from shocks to aggregate demand – fails to apply to countries other than Germany. With asymmetry of decision-making, the core or centre country sets European monetary policy to stabilise its own economy, without regard to conditions in the periphery. But in the face of idiosyncratic supply shocks, this may involve *imposing* demand shocks on periphery countries. This can be illustrated graphically as follows.

In Figure 3.1,  $S = S^*$  represents the Short-Run Aggregate Supply in both the centre country (denoted by asterisk) and the periphery. (Note that we plot inflation  $\pi$ ,  $\pi^*$  on the vertical axis and output, measured as the percentage deviation from equilibrium, on the horizontal axis.) Let there be an idiosyncratic adverse shock in the centre country, which shifts its supply curve  $S^*$  up to  $S_u^*$ . If the centre country acts so as to completely stabilise its price level, then output there must contract from  $E$  to  $A$ . But reducing demand in the centre country so that it becomes in line with supply requires that the relative price of its products should be higher than in the periphery. Assuming a fixed exchange rate and stable prices in the centre country, the only way to achieve this is for monetary policy to be tightened sufficiently so as to force prices *down* in the periphery. As shown in the figure, this can be achieved by a leftward shift in Aggregate Demand from  $D$  to  $D'$ , leading to equilibria of  $A$  in the centre country and  $B$  in the periphery, so the anti-inflationary policy of the centre



country imposes a recession on the periphery.<sup>1</sup>

Figure 3.1 may be something of a caricature, but it captures some features of the situation in Europe since 1990 – when Germany suffered a negative productivity shock on unification.

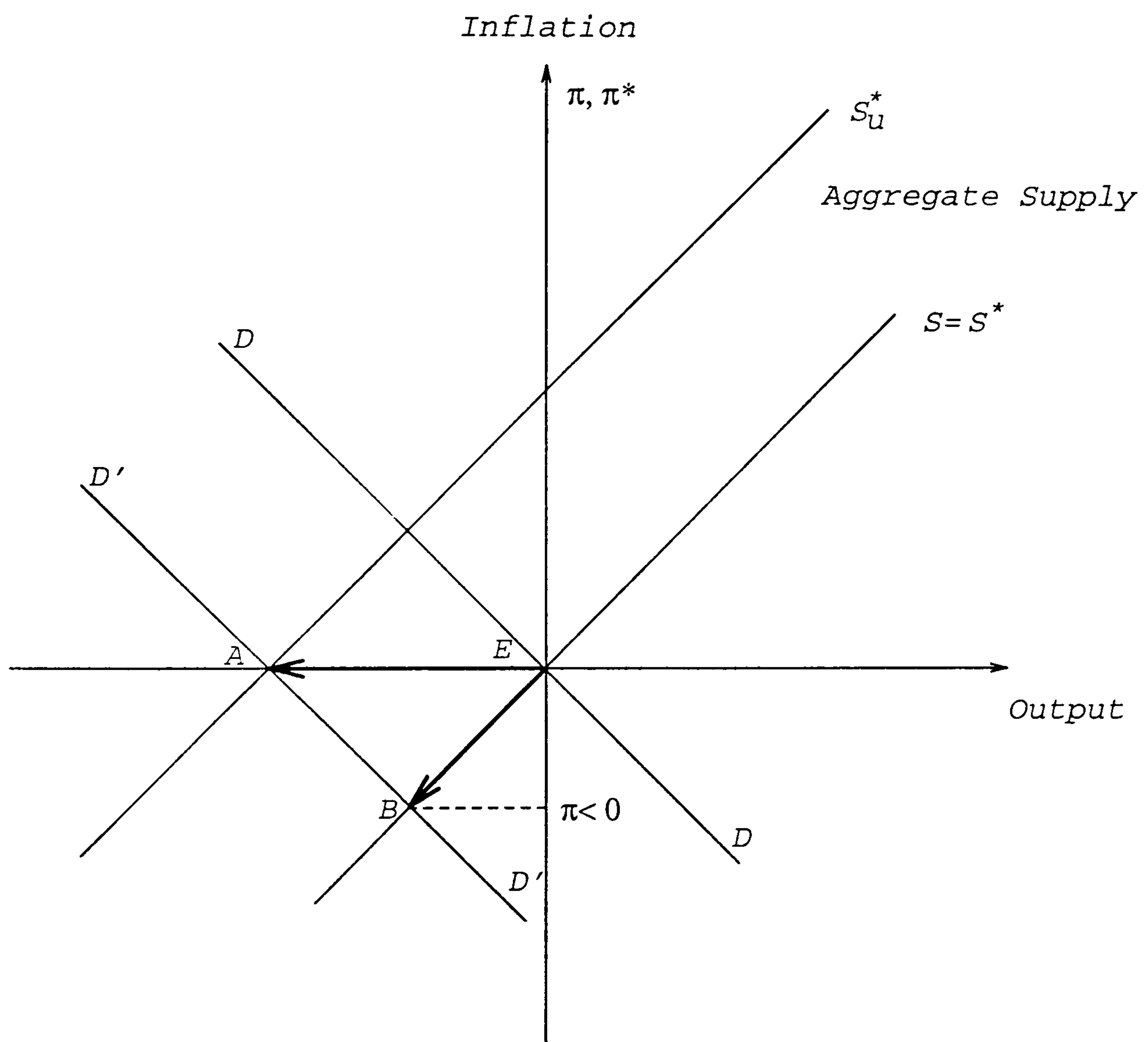


Figure 3.1: How a supply shock in the Core becomes a demand shock in the Periphery.

The restrictive monetary policy emanating from Germany has led to such contrac-

<sup>1</sup>See Appendix A.1 for further details on the algebra of this result.

tion elsewhere that the tight currency links have had to be temporarily suspended – as countries have realigned, floated or settled for very wide bands. By responding in this way, Germany's partners have essentially revoked the delegation of monetary policy to the Bundesbank.

It might, of course, be argued that all this is soon to be superseded. Under the Maastricht treaty there will be no asymmetry – as the European Central Bank does not, in principle, represent any one country. But, is it really plausible that German monetary leadership in Europe will disappear in the near future? Surely Germany will only go along with the Maastricht provisions if they allow her to continue pursuing the objectives of German monetary policy (as would be the case in a two speed Europe, where the DM bloc moved promptly to achieve monetary union).

The problems that asymmetric supply shocks pose for the Maastricht arrangements have also been answered in a number of papers. It is widely understood that, in the case where disturbances are distributed asymmetrically across the countries, there will be a need for an asymmetric policy. Mundell (1961), the precursor of the optimal currency areas theory, considered this problem and noted that an optimal currency area is one in which differential demand shocks *vis -à- vis* other currency blocks are relatively frequent, but within which they are infrequent. The need to accommodate the German re-unification shock has provided new arguments for and against the suitability of EMU. But, if the fall of the wall can be considered as a once



in a lifetime shock, it becomes necessary to discuss more carefully the direction from which new idiosyncratic shocks are likely to come.

Bayoumi and Eichengreen (1992a) provide empirical analysis that reveals a sharp difference between the countries at the centre of the EC, – *the core*: Belgium, France, Germany and the Netherlands, – and *the periphery* Greece, Ireland , Italy, Portugal, Spain and the United Kingdom.

A *core* of EC members experience smaller, highly correlated aggregate supply disturbances than the members of the EC *periphery*. There is also some evidence that demand disturbances are more highly correlated across the *core*. In order to weight the magnitude of the difference between the EC members, these authors use the United States (US) monetary union as a standard of comparison. Shocks to the US show considerably more coherence than shocks to the analogous European regions. The same can be said about the size and speed of adjustment to shocks. Furthermore, in a subsequent study, Bayoumi and Eichengreen (1992b) follow the same methodology in order to discuss the case for EMU participation of EFTA countries. They find that, although Austria, Switzerland and Sweden belong with the EC *core*, the same does not apply to Finland, Iceland and Norway, countries which remain in the *periphery*. Hence, the policy implication is that EC countries may find it difficult or, at least, costly to operate in a monetary union.



The theory of optimum currency areas has also established that, if labour and capital can move freely among the regions of the union, adjustment to some kind of economic shocks can be less harmful. The work by De Grauwe and Vanhaverbeke (1991) in this area is illuminating. The difference in the intensity of interregional mobility of labour between the South and the North of Europe is surprising. Although regional differences in *per capita* income tend to be higher in the South than in the North, Northern Europe exhibits a relatively larger regional mobility of labour than does Southern Europe. Between countries of the EC, labour seems to be relatively immobile.

Another way of maintaining a monetary union without real imbalances is fiscal federalism, i.e., a redistribution through an insurance scheme from *favoured shocked* to *adversely shocked* regions. Here the original analysis of Sachs and Sala-i-Martin (1992) is quite relevant. Once again, the US fiscal system appears to play an important role on the stabilisation process of the union by offsetting about a third of a decline in regional personal incomes relative to the national average.<sup>2</sup> In a parallel way, the existing European tax system on regional income suggests that a one dollar shock to regional GDP would reduce tax payments to the EC Government by half a cent. Hence, Europe should seriously consider the need for improving the actual insurance scheme.

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<sup>2</sup>Gros (1996) mentions further research by Goodhart and Smith (1993) and Pisani-Ferry, Italianer and Lescure (1993), which results in lower but still significant estimates.

In summary, as noted by Alesina and Grilli (1992),

“in a situation where the EEC is not completely unified economically and politically, different countries may have substantially different preferences over the conduct of monetary policy. For example, ... countries at the periphery of Europe, such as Greece, Ireland and Portugal may have to pay the highest costs of giving up their monetary independence” (Alesina and Grilli, p.69.)

Furthermore, as Vittorio Grilli emphasised in his presentation in the *Royal Economic Society* meeting at York, April 1993, the problems for periphery countries will be exacerbated if the moves to EMU are sequential because in this case, the first movers will have the advantage of setting the *rules of the game* in their own interest.

### 3.3 Output persistence and delegation

#### 3.3.1 A diagrammatic interpretation

In this section of the paper we first use aggregate supply and demand analysis to illustrate how optimal policy must strike a compromise between a short anti-inflationary bias (which helps to stabilise prices) and a flexible approach to price changes (as needed to stabilise output given supply shocks); then discuss how employment per-



sistence (due to an asymmetry in market power between *insiders* and *outsiders*) can dramatically increase the consequences of policy inflexibility. (For simplicity we only consider the special case of *hysteresis* here, but the algebraic analysis that follows deals with varying degrees of persistence.)

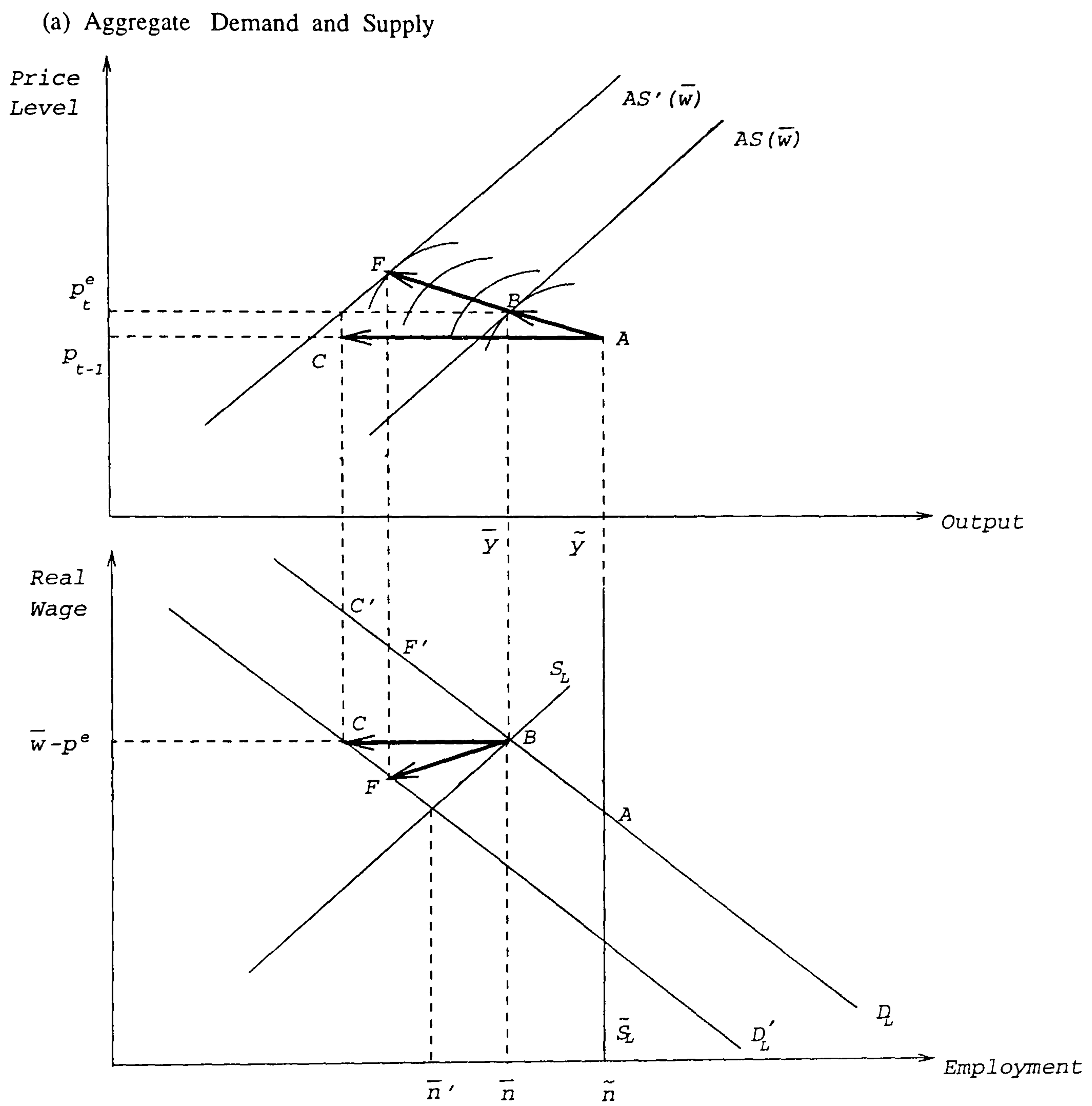
The top panel of Figure 3.2 contains two Aggregate Supply schedules (showing the marginal cost of producing output at a given money wage but with different levels of productivity) and a reaction function ABF, defined by the tangency of the social indifference curves to successive supply schedules. (While output  $y$  is measured in levels, prices are measured in logs, so  $p_t - p_{t-1}$  measures the rate of inflation, and the indifference curves show the tradeoff between inflation and – losses of – output). In the lower panel, where  $n$  denotes the level of employment and  $w - p$  the log of the real wage, one finds the labour market, with the demand for labour  $D_L$  and the supply (in the absence of productivity shocks)  $S_L$  defining market equilibrium at  $\bar{n}$ .<sup>3</sup>

Following Rogoff, however, we *assume that some factor such as income taxation or unemployment insurance distorts the labor-leisure decision and causes the market determined level of employment to lie below the socially optimal level*, (Rogoff (1985a), p. 1173). The *undistorted* labour supply is shown as  $\tilde{S}_L$  in the figure, and it intersects  $D_L$  at  $A$ , which defines  $\tilde{n}$ , the socially optimal level. Output levels marked  $\bar{y}$  and  $\tilde{y}$

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<sup>3</sup>Given declining marginal productivity of labour,  $y = f(n)$  is not a linear function of  $n$ ; so strictly  $y$  and  $n$  are not commensurate. Locally, near  $\bar{n}$ , however, they are, with  $dy \approx f'(\bar{n})dn$ .





(b) The Demand and Supply for Labour

Figure 3.2: Controlling inflation versus stabilising output.

likewise denote market and social equilibria. Because the government is known to care about the shortfall of  $y$  below  $\tilde{y}$ , this imparts an inflationary bias to demand management; point  $B$  in the upper panel shows specifically how the government is tempted to raise prices in order to stimulate output. With rational expectations, however, money wages will incorporate this inflation forecast at the market equilibrium, shown at  $B$  in the lower panel. The extent of this inflation bias clearly depends on the slope of the reaction function  $AB$ : if the government was believed to be more concerned about inflation (flatter  $AB$ ), expected inflation would fall. The idea of delegation to an agency with preferences known to be more conservative than the government seems to be endorsed.

Consider now the impact of an adverse productivity shock which reduces the demand for labour schedule  $D_L$  to  $D'_L$  and shifts the aggregate supply curve upwards from  $AS$  to  $AS'$ . Given that money wages cannot immediately adjust to current inflation and supply-side shocks, the short-run equilibrium depends upon the government's reaction function. Assuming that the government observes the supply shock and is free to adjust the aggregate demand so as to do the best it can in the circumstances (and that its reaction function remains unchanged), the short-run equilibrium occurs at  $F$ , which corresponds to a lower level of employment and output and higher level of prices, i.e., there is stagflation. Note that the unanticipated increase in the price level ensures a decrease in the real wage, so the impact of the negative productivity



shock on employment is partly cushioned; and that (for simplicity) we have assumed no change in  $\tilde{y}$ , the target level of output, in response to the fall in productivity.

If policy were delegated to an *ultra-conservative* monetary authority responsible for price stability (characterised by a horizontal reaction function), the fall of output and employment would be more pronounced than shown so far. Preventing any increase in prices, by applying a contractionary monetary policy, would eliminate the short-run shock absorber of the economy, and with real wages kept constant, employment and output would be at point  $C$ . It is, of course, because of the need for some flexibility to respond to supply shocks, that Rogoff (1985a) concludes that the weight the central banker puts on inflation should not be infinitely greater than society's weighting.

In Rogoff's analysis, however, the end of the supply shock would enable a prompt return to the initial equilibrium at  $\bar{y}$ . Following the traditional approach, he assumes that the wage is unilaterally fixed by the workers, in advance of the realization of the shocks affecting labour demand and supply. But this will not be true if there is persistence as, for example, in the paper of Alogoskoufis, Lockwood and Philippopoulos (1992), hereafter ALP.<sup>4</sup> Following Blanchard and Summers (1986, 1988) and Lindbeck and Snower (1986), ALP assume that nominal wages are set by *insiders*, who aim to achieve an employment target which is a weighted average of the labour force

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<sup>4</sup>See also Lockwood and Philippopoulos (1994).



and those actually in employment when the contract is drawn up, with weights of  $1 - \lambda$  and  $\lambda$  respectively,  $1 \geq \lambda \geq 0$ :

“...where  $\lambda$  measures the extent to which the unemployed are disenfranchised from the labour market. If  $\lambda$  equals one only the employed *insiders* matter for wage setting. If  $\lambda$  equals zero, both the employed and the unemployed get the same weight”, (ALP (1992), p.1375).<sup>5</sup>

As a result, in their model unemployment evolves according to the equation:

$$u_t = \lambda u_{t-1} - \epsilon(\pi_t - \pi^e),$$

where  $\pi_t$  denotes actual inflation,  $\pi^e$  denotes expected inflation and  $\pi^e = E_{t-1}(\pi_t)$  the expected value conditional on information at  $t - 1$ . So,

“...in the extreme case when  $\lambda = 1$ , the unemployment rate stays at its new level until it is displaced by a new shock. In other words, it displays *hysteresis*”, (ALP (1992), footnote 12).

Consider in particular the case of *hysteresis*, when only the employed *insiders* matter for wage setting; in that case employment would remain at whatever equilibrium

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<sup>5</sup>Alternatively, Alogoskoufis and Manning (1988) suggest that the persistence of European unemployment can be attributed to a sluggish labour demand. This might well be a natural consequence of the high costs of employment adjustment in Europe.

was reached initially, even after the shock disappears. *Insiders* can keep their jobs while raising real wages (to levels shown as  $F'$  and  $C'$  in the lower panel). What this suggests is that employment persistence could substantially increase the cost of policy inflexibility, thus implying that less conservatism is desirable. On the other hand, when employment persists, a small increase in current inflation not only reduces today's employment gap, but it also has future benefits in terms of lower unemployment. Indeed, Lockwood and Philippopoulos (1994) show how the inflationary bias associated with discretionary monetary policy increases when unemployment persists.<sup>6</sup> Therefore, to control the larger inflationary bias of the dynamic model, a more conservative central banker is proposed. What is, therefore, the optimal degree of *conservativeness* for the central banker? In the following two sections we consider these issues algebraically.

### 3.3.2 A formal model without persistence

Before studying the dynamic case, consider the following one period model.<sup>7</sup> Assume that the social loss function is the expected value of a misery index, defined as the sum of the squared deviations of the inflation rate  $\pi$  and the level of output  $y$  from

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<sup>6</sup>See also Lockwood and Philippopoulos (1994) for a study on precommitment monetary equilibria in the presence of unemployment persistence.

<sup>7</sup>Here time subscripts have been suppressed for notational convenience.



their target values (zero and  $k\bar{y}$ , respectively), so that:

$$M = \pi^2 + (k\bar{y} - y)^2, \quad (3.1)$$

where  $\bar{y}$  is the expected market clearing equilibrium and  $k > 1$ .

The presence of nominal contracts set at the start of the period leads to an aggregate supply curve that ascribes deviations in output from  $\bar{y}$  to errors in forecasting inflation and to supply-side shocks, that is:

$$y - \bar{y} = \alpha(\pi - \pi^e) + u, \quad (3.2)$$

where  $\pi^e$  denotes expected inflation,  $\alpha$  represents the degree of nominal inertia in the economy, and  $u$  is a supply side shock following a normal distribution with zero mean and variance  $\sigma_u^2$  and zero serial correlation.

#### 3.3.2.1 Commitment to the optimal feedback rule

On the assumption that the government can respond to realizations of the supply shock  $u$ , and that  $\pi^e$ , representing wage setting, is determined before  $u$  is known, then, were the government able to precommit, it could implement the optimal state-contingent rule for the inflation rate. The precommitment solution – *second-best* – is such that the government internalises the effects that its decision rule has on people's



expectations, i.e., it minimises the social loss function (3.1) subject to (3.2) and to the rational expectations condition:

$$E\pi = \pi^e. \quad (3.3)$$

Substituting (3.2) and (3.3) into (3.1), the first order condition (hereafter FOC) with respect to  $\pi$  implies

$$\pi = \alpha(1 - E) [(k - 1)\bar{y} - \alpha\pi + \alpha E\pi - u]. \quad (3.4)$$

Taking expectations on (3.4) gives

$$\pi^e = 0. \quad (3.5)$$

Combining (3.5) and (3.4) provides us with the optimal feedback rule

$$\pi = -\frac{\alpha u}{1 + \alpha^2}, \quad (3.6)$$

so that output is given by

$$y = \bar{y} + \frac{u}{1 + \alpha^2}. \quad (3.7)$$

The average inflation rate will equal the socially desired inflation rate, while average output equals the natural rate. The optimal stabilisation policy provides optimal

variability of output relative to inflation. Inflation decreases with the supply shock in order to soften the supply shock's effect on output.

### 3.3.2.2 Discretion

In the absence of precommitment the government no longer internalises the effect of its decisions on inflation expectations, i.e., it minimises  $M$ , given  $u$  and  $\pi^e$ . This implies:

$$\pi = \frac{\alpha[(k-1)\bar{y} + \alpha\pi^e - u]}{1 + \alpha^2}, \quad (3.8)$$

and so, on substituting from (3.2) above,

$$\pi = \alpha[k\bar{y} - y], \quad (3.9)$$

see Blanchard and Fischer (1989), p.609.

The average inflation rate is, therefore, positive, given by:

$$\pi^e = E\pi = \alpha(k-1)\bar{y}. \quad (3.10)$$

Average output is still equal to the natural rate,

$$y = \bar{y} + \frac{u}{1 + \alpha^2}. \quad (3.11)$$

The discretionary equilibrium delivers optimal stabilisation at the cost of an inflation bias:  $\alpha(k-1)\bar{y}$ .

### 3.3.2.3 Delegation

The potential gains from delegating power to a conservative central banker, *third-best* solution, can be seen by changing the reaction function in (3.9) above to that of the central bank, namely:

$$\pi = \gamma\alpha(k\bar{y} - y), \quad (3.12)$$

where  $\gamma$ , the reaction coefficient, is strictly less than one.<sup>8</sup> The expected level of inflation is thus reduced to  $\gamma\alpha(k-1)\bar{y}$ , which is the principal reason for appointing a conservative head to the central bank. To see how delegation affects stabilisation, however, note that from (3.2) and (3.12), given  $\pi^e = \gamma\alpha(k-1)\bar{y}$ , we find that devia-

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<sup>8</sup>It should be noticed that the reaction function in (3.12) arises after minimising a social loss function of the form:

$$M = \lambda_b\pi^2 + (1 - \lambda_b)(k\bar{y} - y)^2, \quad (3.13)$$

where the parameter  $\lambda_b$ ,  $1 \geq \lambda_b \geq 0$ , which measures the central bank's degree of aversion to inflation, is strictly greater than 1/2. Were the model written in this way,  $\gamma$  would equal:

$$\gamma = \frac{1 - \lambda_b}{\lambda_b}. \quad (3.14)$$



tions of output from  $\bar{y}$  depend on the supply-side shock, divided by  $1 + \gamma\alpha^2$ , i.e.,

$$y - \bar{y} = \frac{u}{1 + \gamma\alpha^2}. \quad (3.15)$$

Clearly, lowering  $\gamma$  increases the sensitivity of the economy to these shocks, which is why Rogoff warns against setting  $\gamma = 0$ . Ideally the central banker would have a reaction coefficient  $\gamma^*$  which minimises  $E(M)$ . Note that, after substitution, the social loss function can be rewritten as:

$$M = (1 + \alpha^2\gamma^2) \left[ (k - 1)\bar{y} - \frac{u}{1 + \gamma\alpha^2} \right]^2. \quad (3.16)$$

So the expected loss function is:

$$E(M) = (1 + \alpha^2\gamma^2) \left[ (k - 1)^2\bar{y}^2 + \frac{\sigma_u^2}{(1 + \gamma\alpha^2)^2} \right]. \quad (3.17)$$

Setting the derivative of this loss function with respect to  $\gamma$  equal to zero gives the necessary condition for the optimal feedback coefficient  $\gamma^*$ , namely:

$$\frac{K}{(1 + \alpha^2\gamma^*)^3} = \frac{\gamma^*}{1 - \gamma^*}, \quad (3.18)$$

where  $K = \sigma_u^2/\delta^2$ , using  $\delta^2 = (k - 1)^2\bar{y}^2$  to denote the squared *distortion* in output.

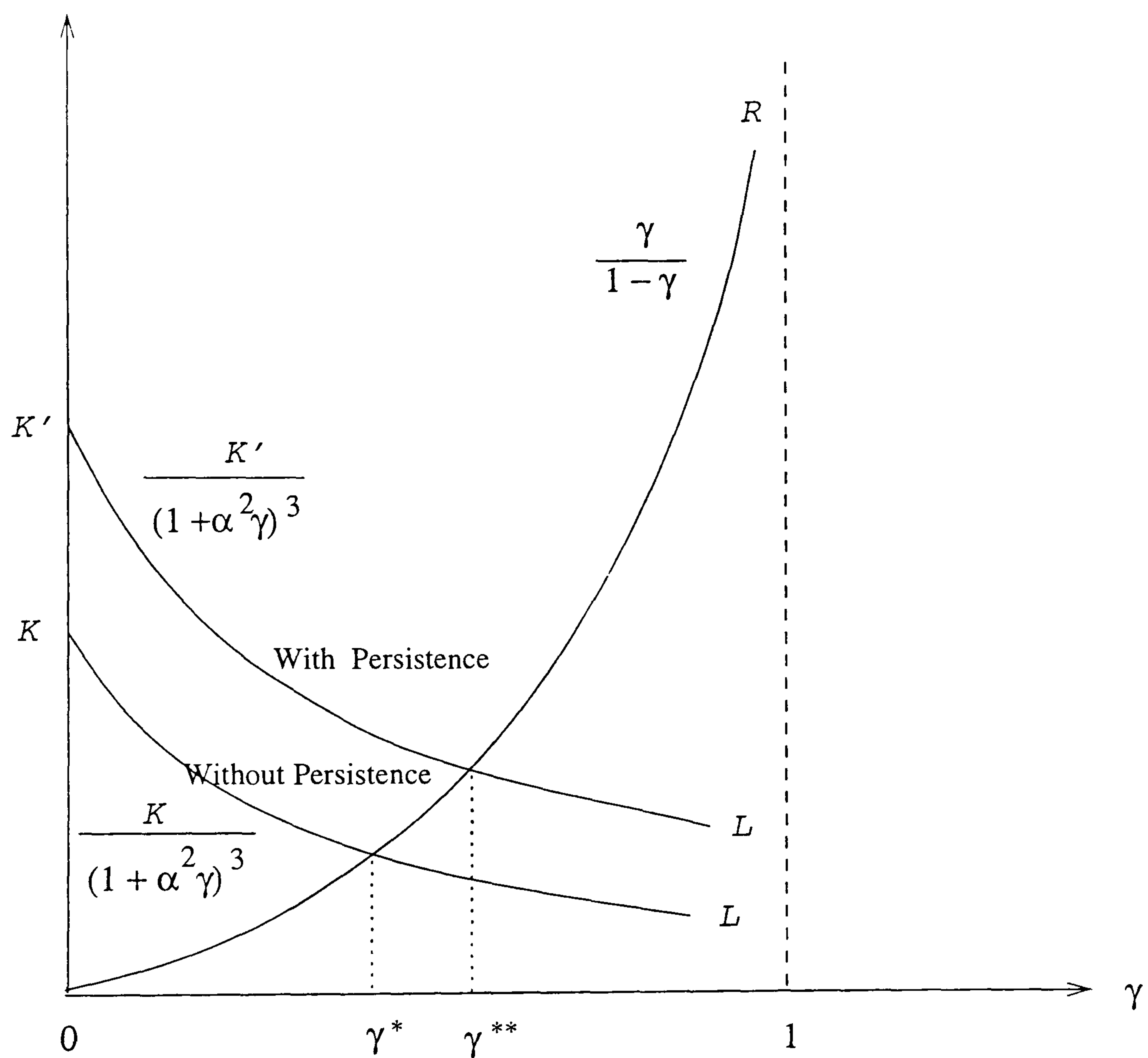


Figure 3.3: Determining the optimal value of  $\gamma$  with and without persistence.

The determination of  $\gamma^*$  — the Rogoff's result — is illustrated in Figure 3.3 where the LHS of (3.18) is plotted as the curve  $KL$ , a decreasing function of  $\gamma$ ; and the RHS is shown by the increasing function labelled  $OR$ . Clearly any increase in  $\sigma_u^2$  will increase  $K$  and shift  $KL$  upwards, leaving  $OR$  unchanged, implying that a more flexible rule is desirable.

### 3.3.3 Optimal delegation with output persistence

Consider now a multi-period extension, shown formally in the Appendix A.2. In the model without persistence, the delegation problem consists of choosing an optimal feedback rule, fully characterised by  $\gamma^*$ . In the dynamic case, however, the delegation problem acquires different significance: the interest rate at which the government and the central bank discount the future,  $\theta$  and  $\theta_b$  respectively, constitutes an issue of major importance. The reason for this is straightforward: in the equilibrium, a small increase in current inflation not only increases today's output but also future levels since output benefits persist. In our model we allow the government to choose  $\theta_b$ . Specifically, we seek to identify that feedback rule with which the government would like to endow the central bank, in circumstances where  $\theta_b$  is extremely large. In other words, the government chooses to appoint a *myopic* central bank.

This surprising choice is merited by the analysis in Lockwood and Philippopoulos (1994), which contains essential background to our analysis. Let us devote some



attention to it.

Lockwood and Philippopoulos (1994) obtain the discretionary and reputational equilibria for a monetary policy game with employment persistence. In particular, employment persistence arises from a monopolistic trade union with an employment target,  $l_t^u$ , that is a weighted average of those *insiders*, who have been recently employed,  $l_{t-1}$ , and the total labour force,  $n$ :<sup>9</sup>

$$l_t^u = \alpha l_{t-1} + (1 - \alpha)n.$$

Hence, the payoff to the union depends negatively on the deviations of actual employment from the target ( $l_t^u - l_t$ ):

$$P = -\frac{1}{2} \sum_{t=1}^{\infty} \delta^{t-1} (l_t^u - l_t)^2,$$

where  $0 < \delta < 1$  is the social discount factor.

A social loss function that depends upon the deviations of actual employment ( $l_t$ ) and inflation levels ( $p_t - p_{t-1}$ ) from target numbers ( $n$  and 0, respectively) is also

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<sup>9</sup>Note that, in this case, there would be temporary rather than permanent employment persistence.

proposed:

$$L = -\frac{1}{2} \sum_{t=1}^{\infty} \delta^{t-1} [\lambda(l_t - n)^2 + (1 - \lambda)(p_t - p_{t-1})^2],$$

where  $0 < \delta < 1$  captures, again, the society's intertemporal preferences, and  $0 \leq \lambda \leq 1$  is the relative weight that society places on the employment target,  $l_t$ .

The model is completed with a labour demand equation,

$$l_t = \psi(p_t - w_t),$$

that determines the level of employment at time  $t$  ( $l_t$ ) as a function of the real wage ( $w_t - p_t$ ).

Lockwood and Philippopoulos (1994) solve for the discretionary and reputational equilibria of the model, and explore how the equilibria inflation rate are changed by the employment dynamics. We focus on the discretionary solution. First, the incorporation of lagged employment into the union's target converts the game from a repeated game into a dynamic game. As a consequence, the authors focus, as normally in these complex environments, on equilibria in Markov strategies.<sup>10</sup> Second, multiplicity of equilibria arise, as may happen in infinite horizon games, based on Markov perfect equilibria. In presence of employment persistence, Lockwood and

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<sup>10</sup>In Chapter 5 we explain in detail what the general properties of Markov perfect equilibria are, and how to tackle them.

Philippopoulos (1994) show that two equilibria arise, if and only if:

$$\frac{(1 + \lambda) - 2\sqrt{\lambda}}{1 - \lambda} \geq \delta\alpha^2 > 0.$$

As long as this existence condition is satisfied, there will exist a well-behaved, low inflation equilibrium, characterised by the following inflationary bias,

$$\pi_t^- = \frac{\lambda + \mu^-}{1 - \lambda} \alpha(n - l_{t-1}),$$

where

$$\mu^- = \frac{(1 - \lambda) - (1 + \lambda)\delta\alpha^2 - \sqrt{\Omega}}{2\delta\alpha^2},$$

and

$$\Omega = (1 - \lambda)^2(1 + \delta^2\alpha^4) - 2(1 - \lambda^2)\delta\alpha^2.$$

A less intuitive, high inflation equilibrium,  $\pi_t^+$ , also arise. In that case, the inflationary bias will be given by:

$$\pi_t^+ = \frac{\lambda + \mu^+}{1 - \lambda} \alpha(n - l_{t-1}),$$



where

$$\mu^+ = \frac{(1 - \lambda) - (1 + \lambda)\delta\alpha^2 + \sqrt{\Omega}}{2\delta\alpha^2}.$$

Although the authors provide some intuition for the high inflation equilibrium, the comparative statics properties possessed by the low inflation equilibrium are far more consistent with economic intuition. Therefore, we focus on the latter.

In the presence of unemployment ( $n > l_{t-1}$ ), the inflation bias associated with the discretionary equilibrium will be above the socially desired level ( $\pi_t^- > 0$ ). Furthermore, combining the existence condition and the solution for  $\pi_t^-$  guarantees that  $\mu^-$  is decreasing in  $\delta\alpha^2$ , so that the inflation bias is decreasing in the insider power ( $\alpha$ ) and the discount factor ( $\delta$ ). The higher the persistence of the employment gap (the higher  $\alpha$ ) or the more the bank cares about the future (the higher  $\delta$ ), the greater the incentive to lower the current employment gap, and so the greater the incentive to inflate now. Hence, in terms of our model, if the inflationary bias decreases with the discount rate  $\theta$ , it seems reasonable to wish to appoint a central banker with a large  $\theta_b$ . Yet, we still need to find out how the optimal central bank's reaction function should look like.

As shown in the Appendix A.2, optimal delegation to a myopic central bank will still be characterised by  $\gamma^{**}$ , as given in Equation (3.12). We shall, therefore, need a

pair of parameters  $(\gamma^{**}, \theta_b)$  to describe the central bankers behaviour and preferences.

With output persistence, the aggregate supply equation can be rewritten as:

$$y - \bar{y} = \rho(y_{t-1} - \bar{y}) + \alpha(\pi - \pi^e) + u, \quad (3.19)$$

where  $1 \geq \rho \geq 0$  and  $y_{t-1}$  denotes lagged output. We find that, as the failure to stabilise output now has much more lasting consequences, the optimal value of  $\gamma$  increases with  $\rho$ . Specifically, on the assumption that  $y_{t-1} = \bar{y}$ , the formal analysis in the Appendix A.2 gives the simple result that the optimality condition for delegation (3.18) should be modified to read:

$$\frac{K'}{(1 + \alpha^2 \gamma^{**})^3} = \frac{\gamma^{**}}{1 - \gamma^{**}}, \quad (3.20)$$

where

$$K' = \frac{1 + \theta}{1 + \theta - \rho^2} \cdot \frac{\sigma_u^2}{\delta^2}, \quad (3.21)$$

$\theta$  is the social rate of time preference, and  $\rho$  is the measure of persistence. Notice that, if there is no discounting so  $K' = \sigma_u^2 / [(1 - \rho^2)\delta^2]$ , the optimal value of  $\gamma^*$  is found by simply replacing the one period variance  $\sigma_u^2$  appearing in (3.18) by the *asymptotic variance*:  $\sigma_u^2 / (1 - \rho^2)$ . As can be seen from Figure 3.3,  $\gamma^{**} > \gamma^*$ , as persistence in output reinforces the need for policy to accommodate productivity shocks by price



adjustment. (The only exception to this is when  $\theta \rightarrow \infty$  and  $K' \rightarrow K$ , so that  $\gamma^{**} = \gamma^*$ , as the future consequences of current policy are completely discounted.)

Figure 3.4 illustrates this point for different levels of  $\sigma_u^2$ . On the horizontal axis is measured the optimal reaction coefficient  $\gamma^{**}$ , ranging from zero to one; and on the vertical axis is  $\rho^2$ , the squared of the degree of persistence,  $1 \geq \rho \geq 0$  (the assumed rate of discount is 5%, the parameter  $\alpha$  equals one – for simplicity – and the condition used to calculate  $\gamma^{**}$  is Equation (A.29) in the Appendix A.2, where  $\epsilon_{t-1} = 0$ , i.e., it is the value of  $\gamma^{**}$  which minimises unconditional expected losses).

The schedules  $AA$ ,  $BB$ ,  $CC$  show how  $\gamma^{**}$  increases with  $\rho$  for  $\sigma_u^2 = \delta^2/4$ ,  $\sigma_u^2 = \delta^2/2$  and  $\sigma_u^2 = \delta^2$ , respectively. The rightward shift from  $AA$  to  $CC$  along the horizontal axis (where  $\rho = 0$ ) illustrates Rogoff's point – that raising  $\sigma_u^2$  (relative to  $\delta^2$ ) reduces the conservative bias in the ideal feedback rule. The rightward bending of these curves is the point we emphasise in this paper – that output persistence can greatly reduce the attractions of inflexible delegation of monetary policy.

Lockwood *et al.* (1994) build on an earlier version of this paper to extend the analysis of delegating monetary policy in an *insiders-outsiders* model in a number of interesting directions. In particular, they consider the so-called *full* delegation problem, a more general case than the one shown above as they also look for the central bank's optimal discount rate.



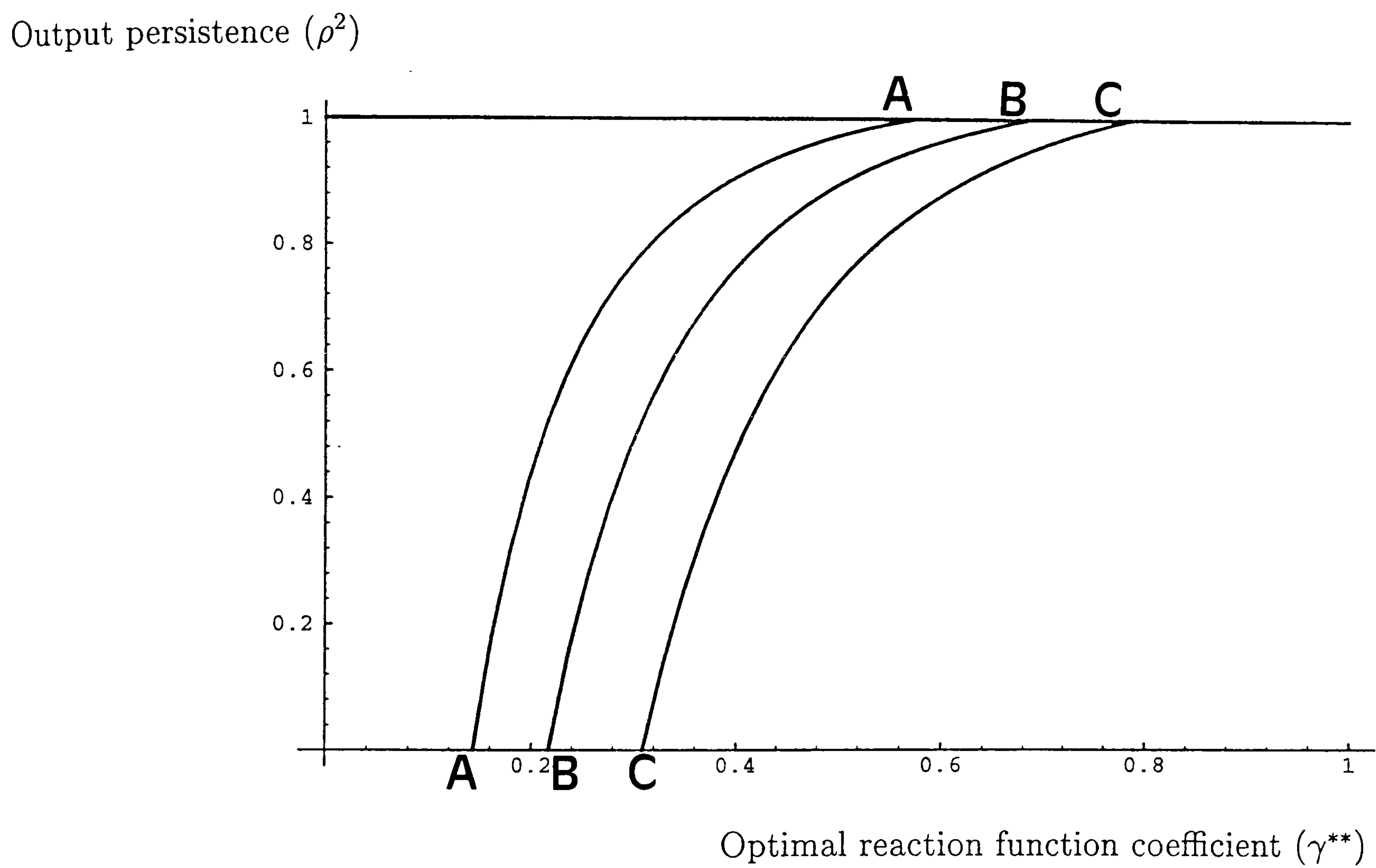


Figure 3.4: How the optimal reaction coefficient varies with  $\rho^2$  and  $\sigma_u^2$ .

Fortunately for our purpose, they find that, if the government appoints a central bank characterised by  $(\gamma^{**}, \theta_b^*)$ , it will always choose a central bank who is myopic,  $(\theta_b^* = \infty)$ , and who is more inflationary averse than the government  $(\gamma^{**} < 1)$ . The intuition for this is clear: a myopic central bank, that discounts the future completely, does not consider the future benefits of lower unemployment and has less incentives to use monetary policy in an opportunistic way. Furthermore, they also find that the coefficient  $\gamma^{**}$ , which characterises the central bank's reaction function, is increasing in  $\rho$ , the degree of persistence. All this would seem to ratify our result.

According to the same authors, however, the myopic central bank's temptation *to expropriate holders of nominal government debt* (Lockwood *et al.* (1994), p. 7.) might be a good reason not to wish to appoint a myopic central bank.<sup>11</sup> Hence, they also consider the case for *partial* delegation where  $\theta_b$  is fixed exogenously, and the government chooses only  $\gamma^{**}$ . In this case, if the central bank is much more far-sighted than the government – as is likely to be the case –, there exists a plausible range of parameters  $(\theta, \theta_b$  and  $\rho)$  such that the government might choose not to delegate, if the need for stabilisation is sufficiently strong. For other ranges of parameters, however, partial delegation to a non-myopic central bank sharply decreases welfare losses. In that case, in order to reduce the inflationary bias, a more conservative central bank is proposed, when  $\rho$  increases. The effects are perverse: it decreases inflation, when

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<sup>11</sup>But this will be superseded under the Maastricht Treaty.

$\rho$  rises, at the cost of less stabilisation.

When output persists, Rogoff's idea of delegation does not seem very attractive. On one hand, the idea of choosing a myopic central bank is very puzzling. On the other, partial delegation to a non-myopic central bank might involve less stabilisation policy as output persistence rises. This last result is particularly inefficient: were the government able to precommit, the optimal policy would involve increasing stabilisation in  $\rho$ .<sup>12</sup>

Clearly, allowing for output persistence exposes the traditional approach to delegation to its major criticism: the policy analysis based only on *ad hoc* incentive structures. As Walsh (1995) has pointed out,

“it is never clear to what extent the economic outcomes and policy trade-offs that arise are inherent in the policy problem or simply arise from the suboptimality of the targeting rules chosen for analysis. For example, by deriving the optimal contract, I show that the trade-off between inflationary bias and suboptimal stabilisation in Rogoff (1985a),... and others arises because these authors place arbitrary restrictions on the targeting rules they consider. This trade-off disappears under the optimal contract; full credibility and flexibility are simultaneously achieved” (Walsh (1995), p.153.)

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<sup>12</sup>See Appendix A.3 for a derivation of the precommitment equilibrium.



Indeed, Lockwood (1996) shows that, when output persists, the precommitment solution can be delivered by a central banker whose payment is inversely related to observed inflation. Following Walsh (1995), he proposes that the government may offer the central bank an employment contract that gives shape to the incentives the central bank faces. In a more recent study, Herrendorf (1995) has suggested a combination of both a *weight* conservative central bank and a feasible optimal incentive contract, as a potential solution for economies where the incentive to create surprise inflation fluctuates significantly.<sup>13</sup> In an alternative study, Svensson (1995) advocates delegation to a both *weight* and *inflation - target* conservative central bank, as a solution to reconcile the flexibility versus credibility problem in models with output persistence. Finally a more promising way of achieving better outcomes than those considered so far has been suggested by Lockwood *et al.* (1995). Based on reputation building factors, *à la* Barro and Gordon (1983), they consider, in a model without output persistence, delegation to a central bank that is more far-sighted than the government. Thus, delegation could achieve better outcomes, if the central bank has more incentives than the government for building a reputation against inflation.

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<sup>13</sup>Here, I follow Svensson's (1995) consistent terminology and refer to a *weight* conservative central bank as one with increased weight on inflation in the social loss function. The alternative, a *inflation target* conservative central bank, requires a monetary authority with an inflation target smaller than the society's desired one.

## 3.4 Conclusions

How relevant are these considerations for EC countries? First of all they (like all other non-German countries) will have suffered from the high interest rates which followed German unification in 1990. Secondly, since countries outside a narrowly defined core (Germany, Benelux plus France) have experienced significant shocks uncorrelated with the EC average, periphery countries should logically prefer more flexibility than core countries for the reasons analysed by Rogoff. In this spirit Alesina and Grilli (1992) warn specifically that

“the countries that have more to lose from a monetary union, from a stabilisation point of view, are the countries at the periphery of Europe.”

(Alesina and Grilli (1994), p.61.)

Last of all, if there is *hysteresis* in European labour markets, then the demand shock coming from high interest rates and the lack of flexibility in response to supply shocks are likely to have prolonged effects. As pointed out by Drazen and Masson (1994), with persistence in unemployment, current anti-inflationary policy may well constraint the room to maneuver in the future. Following a tough policy may actually harm rather than enhance credibility, if the public perceives that the government will not be able to ignore pressures to restore high employment in the future. Policy-makers' intentions are, no doubt, primary for the control of inflation. But the market



structure and the state of the economy should not be ignored when rigorous monetary discipline is advocated.

Presently we are in the second of the three Stages leading to Monetary Union in Europe; so it is important to consider how its provisions are to be implemented. In Stage I Germany's partners responded to the problem of following the Bundesbank's tough lead on monetary policy in three different ways – by doggedly holding the line against the DM (the *franc fort* policy), by floating (as for sterling and the lira) or by realigning (as for the peseta). The lesson drawn by European central banks from these varied responses in Stage I has been the need for more flexibility in the ERM.<sup>14</sup> A realignment of the DM in 1990 would, for example, surely have eased a good deal of the subsequent pressure on Germany's partners. What our analysis suggests is that the same message may well apply to the conduct of exchange rate policy in Stage II and to monetary policy in Stage III.

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<sup>14</sup>Williamson (1992) suggested an asymmetric wide band for the DM as an alternative to the DM realignment.



## Chapter 4

# Controlling inflation in Spain

### 4.1 Introduction

In the late 1970's, the 1980's and 1990's the unemployment rate in Spain has been among the highest in the OECD. This persistence reveals that we deal with a structural problem which, although it has received considerable attention from both labour and macro economists, still awaits a satisfactory explanation.

One can argue that most European countries have experienced the same pattern of increasing and then persistently high unemployment. The breakdown in the unemployment - inflation trade off also suggests an increase in the equilibrium level of unemployment.<sup>1</sup> Nevertheless, the scale of the Spanish problem demands further

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<sup>1</sup>See, for example, Blanchard and Summers (1988).

attention.

“The specificity of the Spanish experience comes from the Franco legacy, which left Spain in the mid-1970’s with both an archaic system of labour relations, and a thoroughly inadequate production structure”.  
(Bentolila and Blanchard (1990).)

The breakdown of labour relations and the wage explosion that arose with the end of Franco’s dictatorship have been blamed for the violent inflation observed in the 1970’s, which led to a peak of nearly 24% in 1977. Simultaneously, affected by the virulence of the oil crisis after 1975, unemployment, which had averaged 1% in the 1960’s, was running at 6.8% in 1978. As a result, in the first half of the 1980’s contractionary aggregate demand policies were implemented. A moderate real wage growth and the reduction in the growth rate of money aggregates were agreed in the *Pactos de La Moncloa*, in order to contribute to a gradual deceleration of the inflationary process. The social consequences of such an anti-inflationary policy are well illustrated by the Spanish unemployment rate, which ran at 21.1% in 1985. Furthermore, as a result of the second oil crisis, the inflation rate was still running at 8.8% during that year.

According to Bentolila and Blanchard (1990)<sup>2</sup>, the increase in unemployment at

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<sup>2</sup>See also Dolado *et al.* (1986), Andrés *et al.* (1990) and Jimeno *et al.* (1994).

work in the early 1980s, was mainly due to this non accommodating stance of monetary policy.

Table 4.1: Unemployment Rates

|         | 1978 | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 | 1994 | 1995 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Canada  | 8.3  | 7.5  | 10.9 | 11.2 | 9.5  | 7.7  | 8.1  | 11.3 | 10.3 | 9.5  |
| U.S.A.  | 6.0  | 7.0  | 9.5  | 7.4  | 6.9  | 5.4  | 5.6  | 7.5  | 6.0  | 5.5  |
| Japan   | 2.2  | 2.0  | 2.4  | 2.7  | 2.8  | 2.5  | 2.1  | 2.2  | 2.9  | 3.1  |
| France  | 5.2  | 6.2  | 8.1  | 9.7  | 10.4 | 10.0 | 8.9  | 10.3 | 12.3 | 11.6 |
| Germany | 3.5  | 2.9  | 5.9  | 7.1  | 6.4  | 6.2  | 4.8  | 4.6  | 8.4  | 8.2  |
| Italy   | 7.1  | 7.5  | 8.4  | 9.4  | 10.5 | 11.0 | 10.3 | 10.5 | 11.1 | —    |
| Sweden  | 2.2  | 2.0  | 3.5  | 3.4  | 2.8  | 1.9  | 1.8  | 5.8  | 9.8  | 9.2  |
| Norway  | 1.8  | 1.6  | 2.6  | 3.1  | 2.0  | 3.2  | 5.2  | 5.9  | 5.4  | 4.9  |
| U.K.    | 5.9  | 6.4  | 11.3 | 11.7 | 11.2 | 8.6  | 6.9  | 10.1 | 9.5  | 8.7  |
| Spain   | 6.8  | 11.1 | 15.6 | 19.7 | 20.8 | 19.1 | 15.9 | 18.1 | 23.8 | 22.7 |

Source: Quarterly Labour Force Statistics, OECD, 1996, No.1.

From 1986 to 1990, the unemployment rate fell substantially to reach 15.9% in 1990. During this period, aided by Spain's integration into the EEC (1986), the oil price fall and the general good health of the world economy, GDP grew by 5% on average and total employment increased by 3% per year. On the monetary side the deflationary process continued, although the capital inflows and the increased pressure on demand led to an inflation rate of 6.9% in 1990. Finally, in June 1989, Spain joined the EMS in an attempt to import credibility and complete the deflationary process.

Soon after the entrance of the peseta to the EMS, Spanish unemployment started to increase again. Among other factors, the serious loss of competitiveness of the Spanish economy – a result of the disadvantageous movements in both inflation and



exchange rate – and the record levels of real interest rates seem to be responsible for the large increase in unemployment. Yet, it was after the collapse of the EMS in August 1992 when a period of major instability began. Today Spanish unemployment stands at about twice the European average, 22.3% in 1996 (Q.1), while inflation runs at about 4.5%.

The size of the Spanish unemployment rate has been a matter of discussion in both domestic and international fora. In Spain, while there is political consensus about the need to conquer the unemployment problem, there is also widespread political agreement that Spain should pursue the disciplinary policies that could allow it to qualify as an eligible candidate for accession to the EMU, under the conditions stated in the Maastricht Treaty. This latter objective has taken precedence in recent decisions by the Spanish Parliament, and in doing so has overshadowed the unemployment issue.

Following the lines in Blanchard *et al.* (1994), reducing the Spanish unemployment rate to 5% within the next decade would imply an annual GDP growth of 5%. To achieve such an ambitious objective, the CEPR Group on Spanish Unemployment has suggested the following strategy. First, it is essential to adopt macroeconomic policies that sustain aggregate demand during the next decade. Second, the fight against unemployment should not be accompanied by inflation. So as to avoid inflationary pressures, these authors propose not the implementation of rigid monetary policy, but the identification of labour market rigidities that, in the late 1980's, expedited

inflation when the rate of unemployment fell to 16%.

Yet, pursuant to the Treaty on European Union, the Banco de España has been granted with the autonomy envisaged in the Treaty for the monetary institutions. The Law of autonomy of the Banco de España, which defines price stability as the primary economic objective of the central bank, and which is intended to mitigate the hypothetical credibility problem suffered by the Spanish monetary authorities, was published on June 2nd, 1994.

As discussed earlier in this thesis, credibility problems have been invoked most often in macroeconomics to explain an alleged inflationary bias in macroeconomic policy-making, and the size of the inflation bias has been proven to depend upon the market structure of the economy. For example, Lockwood and Philippopoulos (1994) demonstrate that the degree of persistence in the unemployment rate – *hysteresis* – characteristic of imperfect competitive labour markets with two different types of workers, the *insiders* and the *outsiders*, reinforces the incentives tempting the monetary institution to create surprise inflation.

Also, in the next two chapters of this thesis, we show that the desynchronisation of the timing in the renegotiation of wage contracts, as well as the length of the contracts themselves, appear to increase the size of the inflationary bias. Finally, the existence of costs of changing prices and *near-rational* behaviour lead to more lasting



effects of monetary surprises, therefore enhancing the credibility problem faced by the monetary authority. In these circumstances, controlling expected inflation is, no doubt, imperative. But to the extent that all these elements represent departures from perfect competitive labour and goods markets, they reinforce the role for active monetary policy stabilisation, if the economy were to be subjected to supply-side shocks. In the previous chapter, we have shown that the optimal precommitment policy involves increasing output stabilisation when output persists. Furthermore, the optimal condition for delegation depends upon the degree of output persistence in the economy. A similar result has been obtained in Waller (1992) for the case of heterogeneous market structure. Hence, if the incorporation of some specific characteristics of the labour and goods markets reinforces the time inconsistency problem of monetary policy, those countries with highly distorted markets will suffer from severe losses when delegating monetary policy to very conservative central banks in the presence of supply-side shocks.

In this chapter we discuss the relevance of these issues for the Spanish economy. In other words, we try to answer the following question: How can Spain control expected inflation and, at the same time, implement *sensible* monetary policy, as needed in the battle against unemployment? Section 4.2 describes some factors that seem to have contributed to endowing Spain with the most distorted labour market in Europe. Section 4.3 discusses how best the mechanisms suggested in the theoretical



literature on the time consistency problem of monetary policy can alleviate the hypothetical credibility problem, to which the Spanish monetary authorities are exposed. Section 4.4 concludes.

## 4.2 Spain: One of the most distorted labour markets in the world

### 4.2.1 Unemployment and its persistence

It is generally accepted that unemployment is in equilibrium only when there is consistency between the intended mark-up of prices over wages and the intended mark-up of wages over prices. Hence, all the theories of unemployment revolve around the so-called, *battle of mark-ups*. There are mainly two mechanisms that can cause unemployment to be high enough so as to prevent the wage-price spiral: the efficiency wage theory of unemployment and collective bargaining with unions. However, these theories cannot explain by themselves the twin movements in both equilibrium and actual European unemployment rates, and substantial research has been undertaken by labour economists in an attempt to identify potential mechanisms at work behind this phenomenon.

Initial research focused on wage setting models where labour demand was unilat-

erally determined by profit maximising firms given a set wage. Then, it was assumed that the wage was unilaterally fixed by the workers, normally in advance of the realization of the shocks affecting labour demand and supply.

The departure from this traditional approach assumed that the wage, at least in expected value, was set so as to keep the relevant membership, *insiders*, at work. The normal assumption in membership models is that membership is closely related to current and past employment.<sup>3</sup>

Alternatively, the employment target would be a weighted average of the labour force and those currently in employment when the contracts are drawn up, where the case for *hysteresis* implies that only employed workers, *insiders*, matter for wage-setting.<sup>4</sup> These approaches are quite reasonable given that, apart from the cases where collective bargaining takes place at the national level, unions seem to act primarily on behalf of employed workers and, perhaps, of those recently or temporarily laid-off. In this context, there would be little pressure on wages to re-enfranchise the unemployed; movements in employment would be highly persistent and short-lived shocks could have long-run effects.

Even if we accept that the wage-setting process takes place between dominating firms and more or less selfish employed workers, one needs to ask what is the role of

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<sup>3</sup>See Blanchard and Summers (1986) and Lindbeck and Snower (1986) .

<sup>4</sup>See, for example, Lockwood and Philippopoulos (1994).



the unemployed in wage determination.<sup>5</sup>

There are various reasons for thinking that the presence of unemployment affects the bargaining power and the decision-making of both firms and employed workers. First, unemployment affects how easy it is for employed workers to find another job, if they were to become unemployed. Poor prospects in the case of job loss will weaken the workers' demand for higher wages. Second, unemployment also affects how easy it is for firms to replace existing workers. In the presence of high unemployment, firms can threaten to turn to the pool of the unemployed for replacement workers, so that unemployment again jeopardises the workers' bargaining power.

But it is often the case that current workers and new hires are not perfect substitutes, as will happen, for example, in the presence of firing and hiring costs. In that event, firms might be reluctant to replace *insiders* by *outsiders* so as not to incur unnecessary costs. Furthermore, current employees and new workers differ in their ability to co-operate with their colleagues. Those currently employed, *insiders*, might be able and prepared to affect the new entrants' productivity by withdrawing co-operation from them. They might also raise the entrants' disutility of work via unfriendly attitudes, a behaviour which is now known as *harassment*. Hence, the possibilities of pursuing both co-operation and harassment activities generate an ability

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<sup>5</sup>Some authors have pointed out that unemployment is not the relevant labour market variable in wage determination, but the present discount value of current and anticipated ratios of unemployment to vacancies. See, for example, Blanchard and Diamond (1992).



difference which can be exploited in the wage determination.

A different type of model explains the persistence of sustained unemployment as a result of the skill and work habit deterioration associated with prolonged unemployment. The evidence of micro econometrics studies suggests that variations in the effectiveness of the unemployed as potential job seekers, provide a clear mechanism for generating persistence.<sup>6</sup> The long-term unemployed, suffering from demoralisation, deskilling, reduced information about jobs, reduced job-search and natural employer discrimination exert less downwards pressure on wages.

If the presence of high unemployment cannot easily discourage highly protected workers from getting large wage increases, the implementation of supply side policies is urgently called for. Furthermore, it is also likely that, without the implementation of suitable labour market reforms, the adoption of aggregate demand policies is interpreted as a signal of future inflation by the financial markets.

#### 4.2.2 The Spanish labour market institutional reform

Simultaneous with the increasing unemployment experience, labour market flexibility became a controversial debate. According to Bentolila and Bertola (1990), during the economic recession that followed the oil price crisis, firms felt constrained by the

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<sup>6</sup>See Bean and Layard (1989).

relatively high costs which they had to incur in order to dismiss workers. The same costs would have been responsible for the firm's reluctance to hire during the 1980's, as they feared facing large severance compensations, if they later had to fire those workers. In consequence, many European governments introduced measures to reduce labour market rigidities.

With respect to Spain, an institutional change occurred in 1984, when a new fixed-term contract, which can be signed for short periods and bear low firing costs, was created.

The fixed-term contract was first introduced into Spanish labour law by the Worker's Statute of 1980. However, it was considered a restricted alternative to the presumed indefinite normal contract. Fixed-term contracts were allowed to exist only when the nature of the activity being undertaken justified doing so – in other words, either to substitute a permanent worker with the right to maintain his or her vacancy, or in order to face activities which are, either temporal, not ordinary, or that imply a sudden increase in the normal activity of the firm. It can, therefore, be said that the Statute maintained the traditional preference for the indefinite contract, and the fixed-term contract remained an exception.

The legislation on employment security was voiced by employers as one of the main obstacles to employment creation. Based on the need, economically inescapable, for



further labour market flexibility, as well as to encourage new job creation, the Worker's Statute Amendment came into place on the 2nd August, 1984. New contract types were introduced: for example, those for training for recent graduates in firms, and for part-time jobs. Most importantly, aided by the so-called Employment Promotion Programme (EPP), a new fixed-term contract was established by the Royal Decree 1989/84, 17th October. Under this agreement firms could hire unemployed workers who were registered in the Employment Office for a minimum of six months (one year since July 1992)<sup>7</sup> up to three years.<sup>8</sup>

Fixed-term contracts were conceived to help to increase the flexibility of what was considered a very rigid labour market. In the presence of massive unemployment,<sup>9</sup> fixed-term contracts with lower adjustment costs were supposed to facilitate hiring and firing practices. The characteristics of the EPP were as follows:

If the fixed-term contract expires and the worker becomes unemployed, he or she receives a severance payment of twelve days' salary per year of service (versus 20 days for permanent contracts). Furthermore, the extinction of the contract cannot be appealed to the labour courts.<sup>10</sup> The law prohibits a firm from filling a vacancy with

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<sup>7</sup>See Law 22/1992, 30th July.

<sup>8</sup>The contracts expiring in 1994 were allowed to be renewed once for a period up to 18 months. See Royal Decree 18/1993, 3rd December.

<sup>9</sup>The Spanish unemployment rate was, in 1985, about 21.1% of the labour force.

<sup>10</sup>In the case of an indefinite contract, the worker is protected against unfair dismissal; the worker being able to receive a severance payment of 45 days of salary per year of service up to a maximum of 42 months.



a fixed-term worker if the vacancy results from another fixed-term contract which expired in the previous year and which lasted the maximum duration. The firm cannot hire a fixed-term worker when a worker has been laid-off or unfairly dismissed in the previous year. There is no limit to the number of fixed-term contracts that a firm is allowed to sign.

For the years 1986-1990, 98% of all contracts registered at the employment offices were fixed-term ones. While in 1987 (2nd quarter), 15.6% of total salary workers' held a fixed-term contract, by 1990 this percentage had increased to 29.8%. The proportion of temporary employees varies across sectors and workers. They are more prevalent for women than for men (34.2% and 27.8%, respectively), for young people (77.9% for those aged 16-19), for less educated workers (36% for illiterates versus 17.3% for university graduates), in agriculture (50.6%) and construction (54%).<sup>11</sup>

The macroeconomic implications for the Spanish economy of the introduction of this new fixed-term contract have been widely investigated. With respect to labour supply, Bentolila and Dolado (1993) analyse how the presence of adjustment costs affect the wage setting process, which in Europe appears to be highly dominated by *insider* employees. These authors set up and tested a model which assumes that temporary workers who *suffer from an unstable attachment to the firm*, are disregarded in wage bargain processes, i.e. they are *outsiders*. They observed three reasons why

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<sup>11</sup>See Segura *et al.* (1991).

fixed-term employees do not participate in the wage bargaining processes equally with permanent workers: (i) *a buffer effect*, arising from the fact that fixed-term workers, bearing lower costs, will be the first ones to be dismissed, (ii) *a composition effect*, because of the potential difference between the two types of workers' wages, and (iii) *a bargaining effect*, composed both of an *harassment* and discipline effect.

Given the extensive use made of fixed-term contracts in Spain, this suggests that the real *insiders* group may be smaller than one would assume. Indeed, in the words of Bentolila and Dolado (1993):

“The flexibility - enhancing measures taken by the Spanish Government have created a two-tier labour market in which temporary employees have little to say in wage formation, at least in manufacturing ... We find that a percentage point increase in the proportion of temporary employment raises the growth rate of permanent worker's wages by on a third of a percentage point.”

In a parallel study based upon dual labour market theory, Alba (1991) demonstrates that an enhanced segmentation process is taking place in the Spanish labour market due to the introduction of fixed-term contracts.

As Alba (1991) stresses, there seems to be two different labour markets: the primary sector, that is rationed and includes stable jobs, with higher wages and better



working conditions, and the secondary sector that comprises low-paid, unstable jobs. Hence, temporary workers, expecting to become permanent, will make a great effort to obtain an indefinite contract. Similarly, those employees more averse to short-term jobs or committed to the firm will work harder to obtain a stable position within the firm. Hence, fixed-term contracts become a cheap recruitment instrument as well as a monitoring tool to elicit greater efforts from the temporary workers.

Conducting a test for a sample of large Spanish firms in 1989, Alba (1991) found that female workers, under 30 and lower educated were more likely to sign fixed-term jobs. He also found an important wage differential between temporary and permanent workers, the former receiving significantly less than the latter. This result is consistent with the following: firms that employ a higher proportion of fixed-term workers pay a lower average wage.<sup>12</sup> This could help to explain the wage moderation observed during the most recent boom between 1985-1990. On the other hand, the fraction of fixed-term employment in the firm appears to have null or negative effects on labour productivity, although the proportion of fixed-term employees among newly hired workers does increase the average productivity of the firm. Furthermore, only around 15% of the temporary workers will get a permanent job once the fixed-term contract has been completed.<sup>13</sup> The trade unions claim that Spain has a very flexible labour

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<sup>12</sup>In Jimeno and Toharia (1992a), fixed-term workers seem to earn about 11% less than permanent employees of similar characteristics.

<sup>13</sup>The figure of the fixed-term contract, as described above, started being revised during the early 1990s; see, for example, Law 22/1992, 30th July, Royal Decree 18/1993, 3rd December, and Law



market. However, the introduction of the fixed-term contract seems to have created a dual segmented market, increased labour turnover and lowered labour productivity. During the recession of the early 1990's, these fixed-term contracts enhanced the power of workers with a permanent job – the real *insiders* – leading to unjustified wage rises.

With regard to labour demand, Bentolila and Saint Paul (1992) focus their theoretical and empirical analysis on the direct effects of adjustment costs of employment on labour demand policies. They analyse the behaviour of the temporary workers — who are allowed to differ in their productivity, wages and firing costs — within a stochastic framework where firms suffer from booms and slumps.

In presence of fixed-term contracts, the optimal policy for a firm suffering from a slump will be characterised, first, by firing temporary workers and, second, by proceeding to reduce the number of permanent jobs, mainly through voluntary vacancies. With regard to the cyclical behaviour of employment within a firm that signs fixed-term contracts — *versus* another where flexible contracts are not available —, the level of employment will be larger during booms but will tend to decrease more significantly during slumps. If the economy suffers from a general recession, the decrease in the level of employment will be larger and the recession shorter in an economy with fixed-term contracts. In other words, the model predicts that the availability of

fixed-term contracts increases the size of total employment's response to aggregate shocks, while decreasing its persistence.

This increased elasticity of employment finds empirical support in a panel of Spanish manufacturing firms in 1985–88: the lower firing costs entailed by the fixed-term contracts would have been responsible for an increase in employment of 1.5% points over these three years. But employment does not appear to be significantly less persistent after flexible labour contracts were extensively used! On the contrary, the degree of unemployment persistence for the Spanish economy is extremely high, close to the *full hysteresis* hypothesis.

There is no single cause for Spanish unemployment to be so high. Unfortunately, the inefficiencies inherited from Franco's legacy had to be reformed at a moment of international economic crisis in the mid-1970's and early 1980's. In the hope of easing the political transition from dictatorship to democracy, government and employers tried to satisfy workers' wage claims. Unemployment increased sharply and, in order to ensure the participation of the unions in a national agreement to enforce lower wages, the government provided generous unemployment protection, which would later be regarded as a significant source of unemployment persistence.

The distorting effects of the labour market reform in 1984, and the role played by the demand policy must be also taken into account. After some years of success



in the war against unemployment, the combination of tight monetary policy, trying to import credibility from the Bundesbank, pro-cyclical fiscal policy and significant wage increases has been held responsible for the immense pool of unemployment. According to Dolado and Jimeno (1995), an expansionary stand for monetary policy and the implementation of supply-side reforms are the two necessary elements to overcome the high Spanish unemployment rate. Labour market reforms, intended to enhance the flexibility of the labour market, are already on their way. But, how can the Spanish authorities provide expansionary monetary policy without putting the anti-inflationary *reputation* of the Banco de España at risk? This is the issue that we discuss in the next section.

### 4.3 Monetary regimes and output persistence: The case for Spain

During recent years the monetary economics literature has produced an important number of papers discussing the implications of the persistence of unemployment. Following the lines of these papers, we could conclude that the high degree of unemployment persistence exposes the Spanish economy to a huge inflation bias. A number of institutional reforms, intended to control inflation, while implementing optimal or sensible stabilisation policies, have been suggested.

In this section we discuss what a simple numerical exercise can teach us about the potential welfare losses suffered by the Spanish economy under different monetary regimes. The four monetary scenarios refer to four different constitutions for the central bank. In particular, we consider the following cases:

- (i) Discretionary case, when the government, chosen democratically by the people, runs monetary policy. In this case, the government chooses the rate of inflation, so as to minimise the following social misery index:

$$V = E_{t-1} \sum_{t=0}^{\infty} \frac{\delta^t}{2} [\pi_t^2 + (y_t - \tilde{y})^2], \quad (4.1)$$

subject to

$$y_t = \rho y_{t-1} + \alpha(\pi_t - \pi_t^e) + u_t, \quad (4.2)$$

where  $y_t$  and  $y_{t-1}$  are deviations from their equilibrium values. As usual in this literature, the public is assumed to dislike deviations of inflation and output from their socially desired levels (0 and  $\tilde{y}$ , respectively). For simplicity, we assume that individuals are indifferent against these two *bads*, i.e., we propose identical preferences for inflation versus output stabilisation.  $\delta$  is the society's discount rate,  $\rho$  is the degree of output persistence and  $\alpha$ , the slope of the



aggregate supply, measures the marginal revenue of inflation.<sup>14</sup>

- (ii) Delegation *à la* Rogoff, when the monetary power is left in the hands of a *weight-conservative*, myopic institution, different from the government. In other words, we consider the social welfare losses (4.1) when the inflation rate is chosen by a central bank that minimises

$$V = E_{t-1} \sum_{t=0}^{\infty} \frac{\delta_b^t}{2} [\pi_t^2 + \lambda_b(y_t - \tilde{y})^2], \quad (4.3)$$

subject to (4.2), where  $\delta_b$  and  $\lambda_b$  are optimally determined as explained in Chapter 3. Note, therefore, that once  $\delta_b$  was set equal to its optimal value, i.e., zero, Equation (4.3) would be simplified to read:

$$V = E_{t-1} \frac{1}{2} [\pi_t^2 + \lambda_b(y_t - \tilde{y})^2].$$

- (iii) Delegation *à la* Svensson, when the monetary policy is run by an *inflation target* and *weight-conservative* central bank. The social losses are evaluated when the inflation rate is determined by a central bank that minimises:

$$V = E_{t-1} \sum_{t=0}^{\infty} \frac{\delta^t}{2} [(\pi_t - \pi_b)^2 + \lambda_b(y_t - \tilde{y})^2], \quad (4.4)$$

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<sup>14</sup>Further algebra on the solution for the discretionary equilibrium with output persistence can be found in Svensson (1995). The original work by Lockwood and Philippopoulos (1994) contains the algebra for the discretionary equilibrium with unemployment persistence.

subject to (4.2), where  $\pi_b$  and  $\lambda_b$  are optimally determined as in Svensson (1995).<sup>15</sup>

- (iv) Commitment solution, when the government itself is able to convince the public about its well-meaning behaviour. Welfare losses under commitment correspond to the *second-best* solution, as derived in Appendix A.3 of this thesis.

### 4.3.1 Calibration results

To get a feeling for the values of the underlying parameters, we proceed as follows. First, the parameter for which we could obtain no empirical estimate, the society's discount rate, was chosen as  $\delta = 0.85$ , which implies a social rate of interest of approximately  $\theta = 0.16$ .

Our estimate for the standard deviation of real GDP is based upon the OECD statistics series, which has estimated a standard error of  $\hat{\sigma}_u = 2.454\%$  for Spain. Observe, however, that this will be an underestimated value of  $\sigma_u$ , the *ex ante* variability of the shock to GDP growth, as some degree of stabilisation policy should have been in force. Furthermore, in order to account for the output persistence effect, given in Equation (4.2), we will recalculate the real output variance by using the formula

$$\sigma_y^2 = (1 - \rho^2)\sigma_u^2.$$

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<sup>15</sup>With persistence, a combination of an optimal state-contingent *inflation target* and a *weight-conservative* central bank can achieve the *second-best* solution, characterised by zero expected inflation and optimal output stabilisation.



Although output and employment are not strictly commensurate, the latter figures have been used as a reference to choose the calibration values of  $y_{t-1}$  – initial deviation of output from the equilibrium – and  $\tilde{y}$  – the equilibrium deviation of output from its desired level. For the initial equilibrium deviation of output we refer to the estimates of the Spanish NAIRU, as in Dolado and Jimeno (1995) and Layard, Nickell and Jackman (1991). These studies place the equilibrium rate of Spanish unemployment around 16 – 20%, implying that inflationary pressures could develop, if the unemployment rate were to fall below this level. These numbers are regarded as a problem by most Spanish people, so we suggest that an unemployment rate around 9 – 10%, close to the EEC average unemployment rate, is desirable. Moreover, the level of Spanish unemployment is currently at around 22%. Hence, for the Spanish economy, the values of  $y_{t-1}$  and  $\tilde{y}$  have been selected within the range  $(-6\%, -3\%)$  and  $(8\%, 3\%)$ , respectively.

As regards the value of  $\rho$ , the evidence is less than uniform, but it seems to be close to the unit root hypothesis.<sup>16</sup> We therefore focus on relatively large degrees of persistence. With respect to the degree of nominal rigidity in the Spanish economy, a value of  $\hat{\alpha} = 0.2$  has been estimated. Like most European economies, Spain seems to suffer from severe real wage rigidity, and long-term nominal contracts appear to be relatively less important to explain the fluctuations of output around the natural

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<sup>16</sup>See Jimeno and Toharia (1992b).

rate.

The figures below represent how social welfare losses respond to changes in  $\alpha$ , the inverse of the Phillips curve's slope, and in  $\rho$ , the degree of output persistence, under different monetary regimes. The four monetary regimes under scrutiny rank as follows:

both commitment and inflation targeting deliver the optimal feedback rule, *second-best*, with zero expected inflation and optimal output stabilisation. Optimal delegation to a *myopic* central bank constitutes the *third-best* solution. It reduces expected inflation at the cost of less than optimal stabilisation. The worst scenario, *fourth-best* coincides with a discretionary policy regime.<sup>17</sup>

Output persistence sensitively decreases social welfare. Figure 4.1(a) illustrates the increase in welfare losses when  $\rho$  varies between 0 and 1.<sup>18</sup> Although delegation and precommitment do not differ too much for low values of  $\rho$ , the benefits from delegation rapidly decline with the degree of persistence. The same applies for increasing values of  $\alpha$ . Figure 4.1(b) shows how the welfare losses vary when  $\alpha$  takes values

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<sup>17</sup>The existence condition,

$$1 \leq \frac{(1 - \delta\rho^2)^2}{4\delta\alpha^2\rho^2}, \quad (4.5)$$

appears in the algebra for the discretionary equilibrium. See Lockwood and Philippopoulos (1994), Lockwood *et al.* (1995) and Svensson (1995).

<sup>18</sup>In Figure (4.1(a)) the real output standard deviation takes the original value,  $\hat{\sigma}_u = 2.454\%$ . When welfare losses are plotted against the degree of output persistence, controlling for the output persistence effect in the variance of real output seriously complicates this exercise.



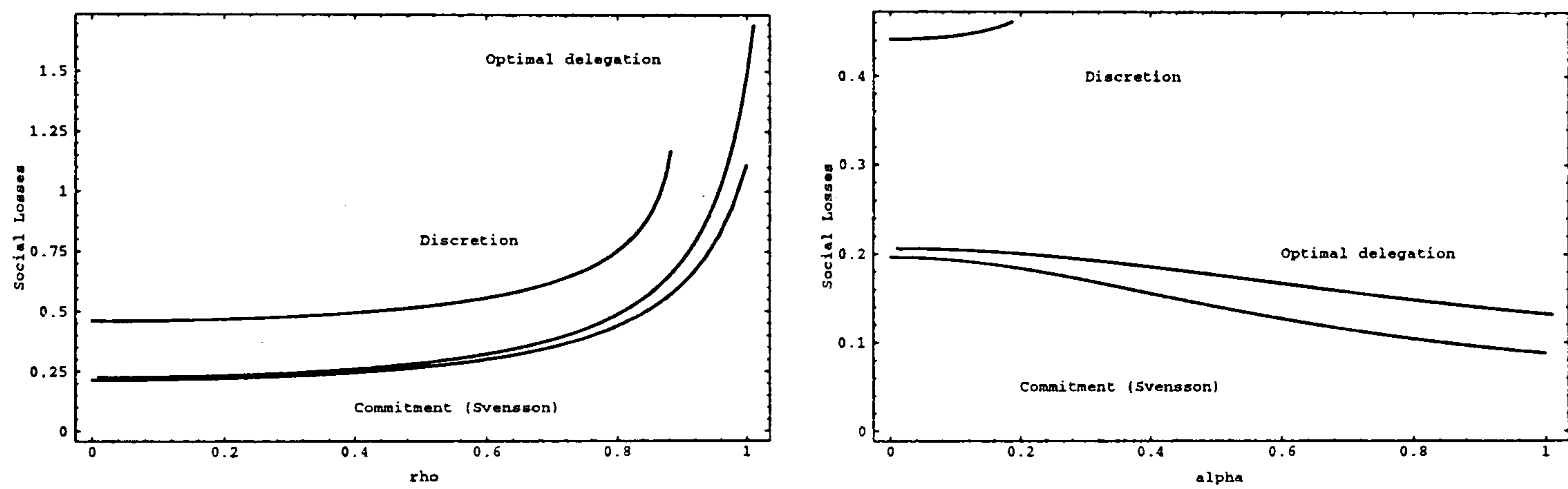
(a) Varying  $\rho$ (b) Varying  $\alpha$ 

Figure 4.1: Welfare losses under different monetary regimes

between 0 and 1. Here, the degree of persistence has been chosen as  $\rho = .8$ , so that  $\hat{\sigma}_y^2 = 0.36 \hat{\sigma}_u^2$ . It should be noted that a large value of  $\alpha$  increases the marginal revenue from an inflationary surprise. If the incentives tempting the monetary authority to inflate are increasing in  $\alpha$ , so must the inflationary bias, and, therefore, the welfare losses. But a large value of  $\alpha$  also facilitates the stabilisation of supply-side shocks, since a smaller amount of inflation is necessary to offset a given productivity shock. Hence, if the government owns a technology that enables it to control expected inflation (through precommitment, inflation targeting or via delegation), welfare losses will decrease in  $\alpha$ .

Our figures emphasise that, for large values of output persistence or nominal rigidity, Rogoff's delegation to a conservative, *myopic* central bank, although still desirable, does not deliver as many goods as expected. Furthermore, social losses increase dramatically if we allow for *partial* delegation to a conservative central banker only, i.e., if the central banker's discount rate is equal to society's.<sup>19</sup> This issue is particularly important for the Spanish economy, which suffers from high unemployment persistence. Indeed, as soon as Spain joined the EMS in June 1989, in an attempt to import credibility from the Bundesbank and, effectively, delegating monetary policy to the German institution, the Spanish unemployment rate started to increase (see Table 4.1).

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<sup>19</sup>See Lockwood *et al.* (1995).



It is more than likely that, during recent years, Spanish monetary policy has been too contractionary, allowing for less than optimal stabilisation. Surely, Spain's membership in the EMS is politically and economically advisable. But, in such circumstances, it is imperative to look at other mechanisms that bring us closer to the *second-best* solution. The economic literature on the institutional design of central banks has suggested optimal incentive contracts and optimal inflation targets as potential tools to overcome this complication. The difficulties of implementing an incentive contract have been already discussed in this thesis. In this section we would like to focus our attention on the inflation target solution, as advocated in Svensson (1995). In the presence of output persistence, Svensson (1995) demonstrates that delegation to a *weight-conservative* central bank with an optimal *state-contingent inflation target* can implement the optimal feedback rule:<sup>20</sup>

$$\pi_t = b^* u_t = -\frac{\alpha}{1 - \delta\rho^2 + \alpha^2} u_t. \quad (4.6)$$

The values of the parameters  $\pi_b$ , the central banker's inflation target, and  $\lambda_b$ , the central banker's weight on preferences, that would induce a central banker to

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<sup>20</sup>See Appendix A.3, for a derivation of the optimal feedback rule, and Svensson (1995), for further details on *inflation target* regimes.

implement the *second-best* policy are given by:

$$\pi_b = g_0 + g_1 y_{t-1}, \quad (4.7)$$

where

$$g_0 = -\frac{\lambda_b \alpha \tilde{y}}{1 - \delta \rho - \delta \alpha \hat{c}}, \quad (4.8)$$

and

$$g_1 = \hat{c} = \frac{1}{2\delta\alpha\rho} \left[ (1 - \delta\rho^2) - \sqrt{(1 - \delta\rho^2)^2 - 4\lambda_b\delta\alpha^2\rho^2} \right] \geq 0. \quad (4.9)$$

Although the inflation target in (4.7) eliminates the inflation bias, it does not deliver optimal inflation response to the supply shock. Hence, optimal output stabilisation has to be achieved through delegation to a *weight-conservative* central bank.

A  $\lambda_b$  is chosen so as to satisfy:<sup>21</sup>

$$\frac{\alpha}{1 - \delta\rho^2 + \alpha^2} = \frac{\lambda_b\alpha + \delta\alpha\hat{c}^2}{1 + \alpha^2\lambda_b - \delta\rho^2 + \delta\alpha^2\hat{c}^2}. \quad (4.11)$$

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<sup>21</sup>It can be shown that an existence condition for feasible  $\lambda_b$  would appear in Svensson's algebra for optimal delegation to an *inflation target* and *weight-conservative* central bank. This condition is more restrictive than the one displayed before and it reads:

$$1 \leq \frac{(1 - \delta\rho^2)^2}{2\delta\alpha^2\rho^2}. \quad (4.10)$$



Table 4.2: Optimal Stabilisation, Inflation target and Conservative Bias

|              | $b^*$ | $\pi_b$ | $\lambda_b$ |
|--------------|-------|---------|-------------|
| $\rho = .94$ | 70%   | -16.2%  | 0.50        |
| $\rho = .8$  | 40%   | -7.6%   | 0.89        |
| $\rho = .7$  | 32%   | -5.6%   | 0.95        |
| $\rho = .5$  | 24%   | -3.6%   | 0.99        |

Other values  $\delta = .85$ ,  $\alpha = .2$ ,  $y_{t-1} = -6\%$ ,  $\tilde{y} = 8\%$ .

|              | $b^*$ | $\pi_b$ | $\lambda_b$ |
|--------------|-------|---------|-------------|
| $\rho = .94$ | 70%   | -6.6%   | 0.50        |
| $\rho = .8$  | 40%   | -3.1%   | 0.89        |
| $\rho = .7$  | 32%   | -2.9%   | 0.95        |
| $\rho = .5$  | 24%   | -1.4%   | 0.99        |

Other values  $\delta = .85$ ,  $\alpha = .2$ ,  $y_{t-1} = -3\%$ ,  $\tilde{y} = 3\%$ .

|               | $b^*$ | $\pi_b$ | $\lambda_b$ |
|---------------|-------|---------|-------------|
| $\alpha = .1$ | 16.8% | -1.1%   | 0.99        |
| $\alpha = .3$ | 44.5% | -3.6%   | 0.89        |
| $\alpha = .5$ | 59.9% | -8.7%   | 0.69        |
| $\alpha = .6$ | 63.6% | -28.7%  | 0.56        |

Other values  $\delta = .85$ ,  $\rho = .7$ ,  $y_{t-1} = -3\%$ ,  $\tilde{y} = 3\%$ .

Table 4.2 presents the values for the parameters  $\pi_b$ , the central bank's inflation target,  $\lambda_b$ , the central bank's conservative bias, and  $b^*$ , the optimal stabilisation coefficient. All the way through our calibrations, we have assumed a social discount rate  $\delta = .85$ . With respect to the degree of persistence,  $\rho$ , and nominal rigidities,  $\alpha$ , statistics are less uniform across countries. The same is true for the initial deviation of output from the natural rate,  $y_{t-1}$ , and for the equilibrium deviation of output from its desired level,  $\tilde{y}$ .

Although the last two variables are not relevant to calculate the optimal stabilisation coefficient,  $b^*$ ,  $y_{t-1}$  and  $\tilde{y}$  do reflect to what extent the monetary authority is tempted to inflate. We allow for different values of  $y_{t-1}$  and  $\tilde{y}$ , keeping in mind that most European countries suffer from too high unemployment rates and from highly distorted labour markets. Furthermore, we should emphasise that the value of the standard deviation of the real output shock does not enter any of the expressions for the coefficients  $b^*$ ,  $\pi_b$  and  $\lambda_b$  –see Equations (4.6), (4.7) and (4.11), respectively. Therefore, the value of  $\hat{\sigma}_u$  is not relevant to this exercise. Intuitively,  $\pi_b$  and  $\lambda_b$  are parameters which *control* the monetary authority's incentives to create a monetary surprise, and such incentives do not depend upon the variance of the output shock. Similarly, the optimal feedback rule says to which extent the society is willing to bear inflation in order to offset a negative output shock. The parameter  $b^*$  measures, therefore, the percentage of the shock that the public is willing to accomodate, and such percentage does not depend upon  $\hat{\sigma}_u$ .

We draw the following conclusions:

the optimal stabilisation coefficient is increasing in  $\rho$ , the degree of output persistence. If supply-side shocks have long lasting effects, the government will find it optimal to stabilise today, in order to avoid losses of output tomorrow. Furthermore, optimal stabilisation is also increasing in  $\alpha$ . If the marginal revenue of inflation increases with the degree of nominal rigidities in the economy, greater stabilisation is



desirable.<sup>22</sup>

But the optimal feedback rule is time inconsistent and cannot be easily implemented without resorting to sophisticated institutional arrangements. Following Svensson's idea of delegation to a *weight-conservative* central bank with the optimal *inflation target* might imply negative values for  $\pi_b$ . For the Spanish case, assuming relatively large values for  $y_{t-1}$  and  $\tilde{y}$ , an inflation target around  $-16\%$  might be necessary! Even when we consider much smaller figures for these variables, the optimal inflation target values around  $-6\%$ .

With respect to other industrialised countries with less distorted labour markets, an inflation target around  $(-3\%, -6\%)$  is urgently called for. Indeed, for EEC countries, like France, Ireland, Italy and Netherlands, the degree of persistence has been estimated to be not smaller than  $\hat{\rho} = 0.8$ . For the U.K., U.S.A. and Canada, the degree of persistence is relatively low –  $\hat{\rho} = 0.5 - 0.6$ . But, when it comes to nominal rigidity, these countries, especially the U.S.A. and Canada, present much larger values for  $\hat{\alpha}$ ,<sup>23</sup> and the size of the inflation target increases more dramatically with  $\hat{\alpha}$ .

Although the calibration exercises should be interpreted carefully, we believe that they are sufficiently honest to support the following discussion. It is hard to think of the way in which this institutional design could be implemented. We observe inflation

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<sup>22</sup>These results have been derived analitically in Chapter 3.

<sup>23</sup>See Layard, Nickell and Jackman (1991).

targeting regimes like those of the U.K., Canada, Spain, Sweden and New Zealand, but we do not observe inflation targeting as advocated in Svensson (1995). What this model predicts is a central bank's inflation target that does not line up with the observed level of inflation. In the real world, however, central banks announce credible inflation targets, which coincide with the observed level of inflation. It has been suggested that the optimal inflation target might be interpreted as a non-linear inflation contract for the central bank. But, if this was the case, we should go back to the discussion on the feasibility of implementing any incentive contract. Finally, a different interpretation for inflation targeting has been presented in Svensson (1996). The most appropriate guide to monetary policy, under inflation targeting, is *inflation forecast targeting*. The idea has some advantages but, as pointed out by Svensson:

It remains to be seen whether a central bank's inflation forecasts can be made so observable and verifiable as to allow sanctions to be conditional on forecasts rather than outcomes. (Svensson (1996), p.21.)

## 4.4 Conclusions

There has been far less empirical than theoretical work on the implications of dynamic inconsistency. When we depart from the the simpler labour market used in Rogoff (1985a), the assumption that monetary policy suffers from a time consistency prob-



lem has two important implications: first, it suggests dramatically large values for the inflation bias, that do not match the inflation levels observed in the real world.<sup>24</sup> Second, institutional design, which has been proposed to reduce expectations for inflation, such as delegation to *weight-conservative* central bankers, inflation contracts or inflation targeting, is difficult to implement. As a whole, the time consistency problem of monetary policy acquires different significance and becomes more troublesome to solve.

The literature on the time consistency problem of monetary policy focuses on normative economics about what central banks *should* do, based upon behavioural assumptions, that may or may not capture what is happening in the real world. What appears to be missed in this literature is a more positive analysis of what central banks actually *do*. This concept is not revolutionary. In the words of Blanchard and Fischer (1989),

There are two questions. First, do governments in fact act in a dynamically inconsistency fashion – or equivalently, do societies suffer as a result of their governments’ inability to precommit themselves to policies? And second, if not, why not – that is, what institutions or constraints on behaviour exist or can be created to mitigate the problem? (Blanchard and Fischer (1989), p.592.)

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<sup>24</sup>In May 1996 Spanish inter-annual inflation was running at 3.8%.

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As emphasised before, the introduction of special characteristics of market structure seriously complicates the design of central bank constitutions, intended to mitigate the credibility problem of monetary policy. On the other hand, the composition of labour and goods markets seems to be of great relevance at the time of quantifying the severity of the time inconsistency problem of monetary policy. Perhaps, one could say that the introduction of microfoundations for wage – and price – setting raises general doubts about the inconsistency model, as a positive theory of macroeconomic policy. Countries like Spain seem to have found ways to institute a reputation for fighting inflation. But, if reputational effects are large enough, the optimal feedback policy could be implemented, so as to avoid further losses of employment.



## Chapter 5

# Overlapping contracts: The consequences of staggered wage setting

### 5.1 Introduction

Many new Keynesian economists have often blamed short-run nominal wage rigidity for causing unemployment in the wake of adverse nominal shocks. Indeed, the impact of aggregate demand on inflation and employment depends, among other factors, on the length of wage contracts and on the speed of adjustment of contracts to new information about the state of the economy. Where there are long-term staggered contracts and absence of synchronised wage setting, changes in monetary policy will

have a much greater effect on employment. Hence, the role for active monetary stabilisation, under staggering, has been defended by Fischer (1977) and Taylor (1979), within a context of time-varying and fixed wage contracts, respectively. Furthermore, many authors have argued that the staggered timing of price adjustment makes output losses inevitable during deflation, because of the inflationary momentum caused by overlapping price and wage decisions.

Nominal wage and price rigidities reflect the empirically common practice of setting wages and prices in money terms for several periods in advance.<sup>1</sup> But multi period contracts are often incomplete, i.e., they are not contingent on nominal wage and price developments elsewhere in the economy. As pointed out by Buiter (1996),

Economic theory has been unable so far to provide a convincing rationalisation of this particular form of incomplete contracting. Indeed, we do not have good theories as to why wage and price contracts tend to use money (the medium of exchange and means of payment) as the *numéraire* (unit of account), rather than some bundle of goods, (Buiter (1996), footnote 13).

In contrast with the new Keynesian theory, new classical economists argue that credibility problems are central to the disinflationary process, so that disinflation would be costless if the government announced credible commitments.

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<sup>1</sup>For a detailed discussion of nominal wage rigidity in OECD countries, see Layard *et al.* (1991).



But, if multi-period contracts lead to more lasting effects of monetary policy surprises, they will enhance the credibility (time consistency) problem of monetary policy. In other words, credibility problems and microfoundations of wage - and price - setting cannot be easily separated for the quantification of the costs of disinflationary policy. Despite the relevance of this problem, to our knowledge, only Levine and Pearlman (1994) have formally incorporated wage setting dynamics into the time consistency literature.<sup>2</sup>

Borrowing heavily from Calvo (1983), these authors analyse real and nominal wage inertia, which arises from the existence of contracts, based upon expectations for future prices and unemployment, extending over many periods. On one hand, for contracts longer than one period, a role for an active monetary policy, even when completely anticipated, emerges. On the other, there is a greater credibility problem. In an attempt at realising the benefits of monetary policy stabilisation, these authors study delegation to a conservative central bank. They show that the *conservatism* of the central banker increases as nominal and real wage inertia increases, and focus on the feasibility of a monetary union.

To our mind, Levine and Pearlman (1994) contribute to the debate on delegation in two important ways. First, it generalises Rogoffs result to a multi-period contract model and highlights how the degree of *conservatism* depends upon the characteristics

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<sup>2</sup>The research reported here was conducted independently of Levine and Pearlman (1994).

of the labour markets. Second, it caveats that labour European markets should not be very different ones, if the benefits of delegation want to be realised.

However, with multi-period contracts, delegation to a conservative central bank does not provide as many goods as we would have hoped for; delegation to a central banker involves less stabilisation policy in the presence of multi-period contracts. This result is particularly inefficient: a role for an active monetary stabilisation emerges for contracts longer than one period<sup>3</sup>. Realising the full benefits of monetary policy stabilisation requires other solutions than delegation. Yet, Levine and Pearlman (1994) simply rule out precommitment solutions and do not explore optimal incentive contracts for the central banker either. Clearly, we believe that further research on precommitment or, alternatively, optimal contracts is needed.

What we propose here is a simple generalisation of the Taylor (1979) model on contracts to show, firstly, how the interaction of staggered and credibility problems generates different series of inflation and output behaviour. Section 5.2 presents the model. In Section 5.3 we obtain the discretionary equilibrium, where the government cannot precommit to a rate of inflation, and compare it to the *static* model with one period contracts. Our findings indicate that the existence of long-term staggered contracts increases the credibility problem of monetary policy. This result mirrors that obtained by Levine and Pearlman (1994), for an economy where nominal rigidities

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<sup>3</sup>See Taylor (1979) and Fischer (1977).



arise from the presence of Calvo contracts. The discretionary policy may be improved by precommitment. In Section 5.4 we depart, to our knowledge, from any previous work and focus on the feasibility of precommitted equilibria. It will be shown that, as wage contracts last for more than one period –where by a period it is meant the length of time between the decisions on monetary policy taken by the central banker–, the central banker will face severe difficulties to deliver zero inflation monetary policy. This is the key result of this chapter. The role for delegation is briefly discussed in Section 5.5, where we refer to the work by Levine and Pearlman (1994). Section 5.6 concludes.

## 5.2 Wage contract models

### 5.2.1 The static model

Prior to studying the dynamic case, consider the following one period wage setting model. The economy evolves over an infinite number of periods. All variables are in logs and real variables represent deviations from their long-run equilibrium levels.

Wage setters select their nominal wage,  $x_t$ , in order to target the real wage. Assuming that the wage setters' target real wage is zero, the contract wage determination

is given by:

$$x_t = \hat{p}_t, \quad (5.1)$$

where  $p_t$  denotes the price at period  $t$  and  $\hat{\cdot}$  the rational expectations operator.

A contract is assumed to specify a fixed nominal wage which will apply for the duration of the contract. The contractually determined money wage will be set equal to the expected market - clearing money wage, based on the known money wage and on individuals' expectations of the average level of prices prevailing in the market. Once wages have been set, the actual supply and demand conditions become known. Then, the actual level of employment equals the actual quantity of labour demanded, i.e., it is assumed that labour demand, the short side of the market, always dominates.

The general level of prices depends upon the underlying nominal wage and demand fluctuations,

$$p_t = x_t + \rho y_t, \quad (5.2)$$

where  $\rho$  represents the output elasticity of the price level. Alternatively, Equation (5.2) can be seen as a downward-sloping labour demand curve, where  $1/\rho$  is the price elasticity of labour demand. Aggregate demand is an increasing function of



real money balances,

$$y_t = m_t - p_t, \quad (5.3)$$

where  $m_t$  is the logarithm of the nominal money supply. The model is completed by specifying an objective function for the government. As is customary in this literature, it is assumed that the government sets its monetary policy, after the wage contract,  $x_t$ , has been determined, in order to minimise a social loss function of the form

$$V_t = \sum_{s=t}^{\infty} \delta^{s-t} [(1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2], \quad (5.4)$$

where  $0 \leq \lambda \leq 1$  captures the weight that the government puts on targeting inflation versus output or, equivalently, employment.  $\tilde{y}$ , the socially desired level of output, is greater than  $\bar{y}$ , the long run equilibrium level of output, which in our model equals zero. Zero is the most preferred level of inflation and  $0 \leq \delta \leq 1$  is the parameter representing the society's inter-temporal preferences.

Possible factors which might cause equilibrium output to lie below the socially desired level include distortions in the labour market such as income taxation, unemployment insurance and monopolistic unions.

As will be shown later, in equilibrium the nominal wage is set at a sufficiently high level so that the monetary authority will not choose to inflate beyond that point

consistent with the wage setters' anticipated rate of inflation. The equilibrium is Nash because the monetary authority finds that the marginal utility from further inflation, that would raise output above the market determined level, is equal to the marginal disutility from added inflation. Furthermore, even if each group of wage setters dislikes inflation, just as society does, they have little incentives to stop their nominal wage increases because the impact of individual contracts on aggregate inflation is negligible.

Solving for the discretionary equilibrium one finds that

$$y_t = 0 \tag{5.5}$$

and

$$p_t - p_{t-1} = \frac{(1 - \lambda)\tilde{y}}{\lambda\rho}. \tag{5.6}$$

### 5.2.2 The dynamic model

Borrowing from Taylor (1979), wage contracts last for two periods and decision dates overlap in the dynamic version. For simplicity, we assume that half of the contracts



are set in period  $t$ , half in  $t + 1$ . The contract wage determination is assumed to be

$$x_t = \frac{\hat{p}_t + \hat{p}_{t+1}}{2}. \quad (5.7)$$

As before, the wage contract is assumed to specify a fixed nominal wage which will apply for the duration of the contract. Hence, workers have to form expectations about current and future prices.

The aggregate price level at  $t$  is determined by the average wage prevailing at time  $t$ ,  $w_t = (x_{t-1} + x_t)$ , together with output fluctuations,

$$p_t = \frac{x_{t-1} + x_t}{2} + \rho y_t, \quad \rho \geq 0. \quad (5.8)$$

Hence,  $p_t$  is homogeneous of degree one (hereafter, HOD 1) in past and current contracts, while  $x_t$  is HOD 1 in current and future prices. The degree of nominal inertia is symmetric in lag and lead contracts.

Aggregate demand depends upon real money balances,

$$y_t = m_t - p_t. \quad (5.9)$$

Using (5.8) and (5.9), we find

$$p_t = \frac{1}{1+\rho} \left[ \rho m_t + \frac{1}{2} (x_t + x_{t-1}) \right], \quad (5.10)$$

$$y_t = \frac{1}{1+\rho} \left[ m_t - \frac{1}{2} (x_t + x_{t-1}) \right]. \quad (5.11)$$

Finally, the objective function for the government is as in (5.4) above.

Due to the presence of long-term staggered contracts, the central bank plays a *dynamic* rather than repeated game with the wage-setters. In repeated games, the simplest and best-understood class of dynamic games, players face the same physical environment in every period, and the players' overall payoff is a weighted average of the payoffs in each period. Dynamic games, however, consider strategies in which the past has some influence on current and future strategies because it has a direct effect on the environment. In these more complex environments, attention is often focused on equilibria in Markov strategies, that is, strategies that only depend on the past history of the game through an appropriately defined state variable, as the state variable summarises the effect of the past on the current environment. Players' strategies are, therefore, restricted to be strategies without memory: *bygones are bygones*, except in so far as they affect the current state variable.

Following this approach, we obtain the Markov perfect equilibrium (MPE), which



has been defined as a *profile of Markov strategies that yields a Nash equilibrium in every period* (Fudenberg and Tirole (1991), p. 501.). However, there can be many other equilibria. For instance, the MPE restriction rules out punishment strategies, which could be used to sustain a low inflation equilibria as in Barro and Gordon (1983).<sup>4</sup>

### 5.3 The time consistent policy rule

Under the MPE restrictions dynamic programming provides a powerful method for studying dynamic optimisation. In particular, to obtain the time consistent equilibrium we will apply Bellman's principle of optimality which states, in this case, that

$$V(z_{t-1}) = \underset{m_t}{\text{Min}} \left[ (1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2 + \delta V(z_t) \right], \quad (5.12)$$

where  $z_t$  is the relevant state variable of the system, and  $V(z_{t-1})$  is the optimised value function for the policy-maker at time  $t$ , given the lagged value for the state variable.

The most important features of this procedure are twofold. First, the solution is characterised by the optimal value of the functional  $V^*$ , rather than by the properties of the optimal control path,  $m_t$ , as in optimal control theory. Second, it embodies the

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<sup>4</sup>See Obstfeld (1990, 1991) for examples of monetary games focused on Markov perfect equilibria.

original problem of optimisation in a family of optimisation sequences, which leads to the development of an iterative procedure that will actually solve for a whole family of problems.<sup>5</sup>

In this game the state variable is chosen to be the inverse of the last wage contract that was written, expressed in real terms. It will be denoted

$$z_t = p_t - x_t. \quad (5.13)$$

As mentioned before, we focus on equilibria in Markov strategies, i.e., strategies that only depend on the past history of the game through an appropriately defined state variable. However, how can we explain that  $z_t$  is the relevant state variable of our problem? Indeed, we could have proposed a more general value function that included separate state variables,  $V(p_{t-1}, x_{t-1})$ . By doing so, we would have allowed  $p_{t-1}$  and  $x_{t-1}$  to enter the value function in a more general form than the one proposed here. Yet, in Appendix B.1 we will show that there exists a solution to our problem in which  $p_{t-1}$  and  $x_{t-1}$  enter the policy maker's (wage setters') reaction function in a difference form, so that the state variable  $z_{t-1}$ , defined in Equation (5.13), captures the effect of the past history of the game on the current environment. Although there may be other MPE that do not have this property, and this should be emphasised,

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<sup>5</sup>See Chiang (1992).



we focus on a solution where a general strategy for the central bank (respectively, wage-setters) is to choose the money supply (wage contract) at every time period as a function of the state variable  $z_{t-1}$ . In addition, the central bank also reacts to the current wage contract  $x_t$ . Hence, the wage setters' reaction function is simply to set

$$x_t = \alpha_0 + \alpha_1 z_{t-1} + p_{t-1}, \quad (5.14)$$

conditional upon the state variable  $z_{t-1}$ .<sup>6</sup> The constants  $\alpha_0$  and  $\alpha_1$  need to be determined and the term  $p_{t-1}$  has to be introduced in order to satisfy the homogeneity properties of  $x_t$ , i.e., it is only the wage contract, in real terms, that matters.

Moreover, we denote as

$$V(z_{t-1}) = \beta_0 + \beta_1 z_{t-1} + \beta_2 z_{t-1}^2 \quad (5.15)$$

the present discounted value of social losses from  $t$  onwards, conditional on the state variable  $z_{t-1}$ , where the coefficients  $\beta_0$ ,  $\beta_1$  and  $\beta_2$  need to be determined.

Then, after substituting (5.15), (5.10) and (5.11) into (5.12), the best response of

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<sup>6</sup>Since the problem is linear quadratic, we look for a solution in which  $V_t(z_{t-1})$  is quadratic, and decision rules are linear.

the central bank to the wage-setters' reaction function is to choose  $m_t$  to minimise

$$\begin{aligned} V(z_{t-1}) = \underset{m_t}{Min} (1 - \lambda) & \left[ \frac{1}{1 + \rho} \left( m_t - \frac{x_t}{2} - \frac{x_{t-1}}{2} \right) - \tilde{y} \right]^2 \\ & + \lambda \left[ \frac{\rho}{1 + \rho} m_t + \frac{1}{2(1 + \rho)} (x_t + x_{t-1}) - p_{t-1} \right]^2 \\ & + \delta(\beta_0 + \beta_1 z_t + \beta_2 z_t^2). \end{aligned} \quad (5.16)$$

where

$$z_t = p_t - x_t = \frac{1}{1 + \rho} [\rho m_t + \frac{1}{2} (x_t + x_{t-1})] - x_t.$$

The optimal monetary policy at  $t$  is characterised by the first order condition to this problem, which, after substituting  $x_t$  in Equation (5.14), can be written as

$$\begin{aligned} m_t = 2A(1 + \rho)(1 - \lambda)\tilde{y} - A(1 + \rho)\delta\rho\beta_1 \\ + B\alpha_0 + Cx_{t-1} + Dp_{t-1} + B\alpha_1 z_{t-1}, \end{aligned} \quad (5.17)$$

where

$$\begin{aligned} A &= \frac{1}{2(1 - \lambda + \lambda\rho^2 + \delta\rho^2\beta_2)}, \\ B &= A \cdot [\beta_2\delta\rho(1 + 2\rho) + 1 - \lambda - \lambda\rho], \\ C &= A \cdot (1 - \lambda - \lambda\rho - \beta_2\delta\rho) \\ D &= A \cdot [(\beta_2\delta\rho + \rho\lambda)(1 + 2\rho) + 1 - \lambda]. \end{aligned}$$



Note that  $C+D=1$ , so that the homogeneity properties of the model are satisfied.

Thus, the optimal monetary policy can be expressed as:

$$m_t = 2A(1+\rho)(1-\lambda)\tilde{y} - A(1+\rho)\delta\rho\beta_1 + B\alpha_0 + p_{t-1} + (B\alpha_1 - C)z_{t-1}. \quad (5.18)$$

Substituting (5.18) into (5.10) and (5.11), making use of  $x_t = \alpha_0 + \alpha_1 z_{t-1} + p_{t-1}$  and simplifying the expressions for inflation and output in terms of the real state variable  $z_{t-1}$ , we get the following:

$$p_t - p_{t-1} = 2A(1-\lambda)\rho\tilde{y} - A\delta\rho^2\beta_1 + \frac{\alpha_0}{1+\rho} \left( \rho B + \frac{1}{2} \right) + \left( \frac{\rho\alpha_1 B - \rho C + \frac{\alpha_1 - 1}{2}}{1+\rho} \right) z_{t-1}, \quad (5.19)$$

$$y_t = 2A(1-\lambda)\tilde{y} - A\delta\rho\beta_1 + \frac{\alpha_0}{1+\rho} \left( B - \frac{1}{2} \right) + \left( \frac{\alpha_1 B - C - \frac{\alpha_1 - 1}{2}}{1+\rho} \right) z_{t-1}. \quad (5.20)$$

To guarantee consistency of the solution and get expressions for  $\beta_1$  and  $\beta_2$ , we must substitute the monetary rule given by (5.18) back into (5.16) and ensure that the coefficients on the state variables in the valuation function are identical to those

of (5.15). In other words,

$$\begin{aligned}
 V_t(z_{t-1}) &= \beta_0 + \beta_1 z_{t-1} + \beta_2 z_{t-1}^2 \\
 &= (1 - \lambda) \left[ \frac{1}{1 + \rho} \left( m_t - \frac{x_t}{2} - \frac{x_{t-1}}{2} \right) - \tilde{y} \right]^2 \\
 &\quad + \lambda \left[ \frac{\rho}{1 + \rho} m_t + \frac{1}{2(1 + \rho)} (x_t + x_{t-1}) - p_{t-1} \right]^2 \\
 &\quad + \delta(\beta_0 + \beta_1 z_t + \beta_2 z_t^2).
 \end{aligned}$$

Furthermore, the parameters  $\alpha_0$  and  $\alpha_1$  in (5.14) must be consistent with those deriving from substituting (??) into (??). This leads to a system of equations for  $\alpha_0$ ,  $\alpha_1$ ,  $\beta_0$ ,  $\beta_1$  and  $\beta_2$ , of which the four relevant ones are presented in Appendix B.2.1.

We now derive the steady state of the system where the rate of inflation is constant, i.e.,  $p_t - p_{t-1} = \bar{k}$ ,  $x_t - x_{t-1} = \bar{k}$ , and, hence,  $z_t = z_{t-1}$ . The long-run (steady state) equilibrium level for the state variable of the system will be characterised by:<sup>7</sup>

$$z_t = \frac{(-1 + \lambda)\tilde{y}(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)}{2\lambda\rho[1 - \lambda + 2\lambda\rho^2 + (\lambda - 1)\delta]}. \quad (5.21)$$

Similarly, the inflationary bias that corresponds to the steady state will be given

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<sup>7</sup>It should be pointed out that, for any value of  $z_{t-1}$ , the state variable,  $z_t$ , immediately jumps to its steady state value, given by Equation (5.21).



by:

$$\bar{k} = \frac{(1 - \lambda)\tilde{y}(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)}{\lambda\rho[1 - \lambda + 2\lambda\rho^2 + (\lambda - 1)\delta]}, \quad (5.22)$$

which is unambiguously larger than the inflationary bias associated with the *static* economy, given by Equation (5.6). Indeed, given  $1 \geq \lambda \geq 0$ , it will be always the case for:

$$\frac{1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2}{1 - \lambda + 2\lambda\rho^2 + (\lambda - 1)\delta} > 1,$$

so that,

$$\bar{k} > \frac{(1 - \lambda)\bar{y}}{\lambda\rho}.$$

This result mirrors that obtained by Levine and Pearlman (1994) for an economy where nominal rigidities arise from the presence of Calvo contracts.

The equilibrium level of output is given by Equation (5.20), once  $z_{t-1}$  has been substituted by its steady state value. As is usual in a time consistent equilibrium, the long-run level of output equals its natural equilibrium level, which in our model equals zero.<sup>8</sup>

In order to discuss the welfare implications of the existence of overlapping con-

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<sup>8</sup>See Appendix B.2.2 for further details on the algebra for the steady state.

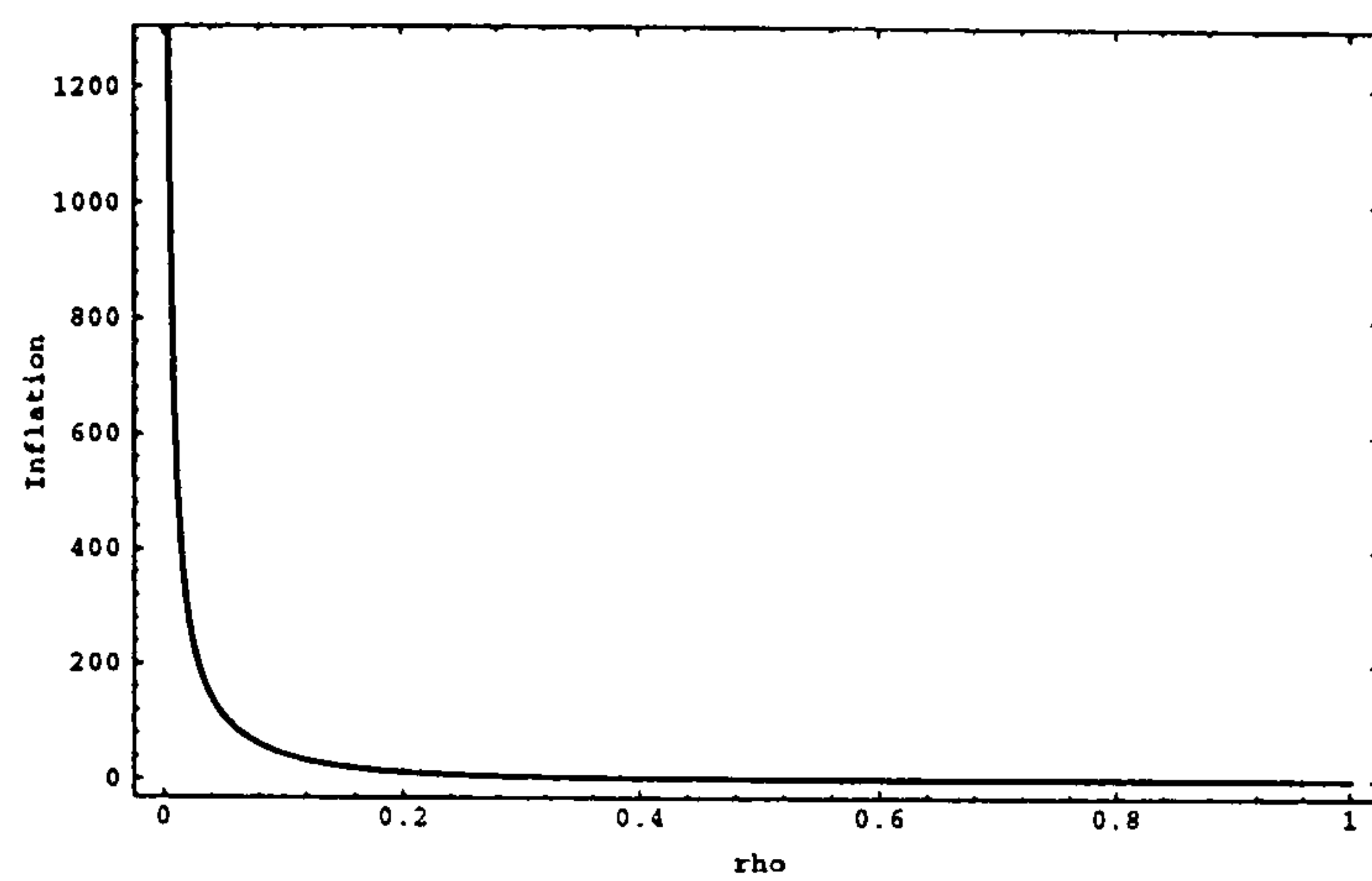
tracts, we compare the time consistent equilibrium of our staggered economy with that obtained from the so called *static* economy, in which wages are set only for a single period. A comparison between the two economies leads to the following results.

First, in the long-run equilibrium, the existence of overlapping contracts does not make any difference in terms of output. As was pointed out above, in both cases, the nominal wage is set at a sufficiently high level so that the government finds it too costly to allow for higher inflation. Despite the presence of multi-period contracts, monetary policy has no real effects in the equilibrium. This is a simple consequence of wage setters' expectations being fulfilled in the steady state.

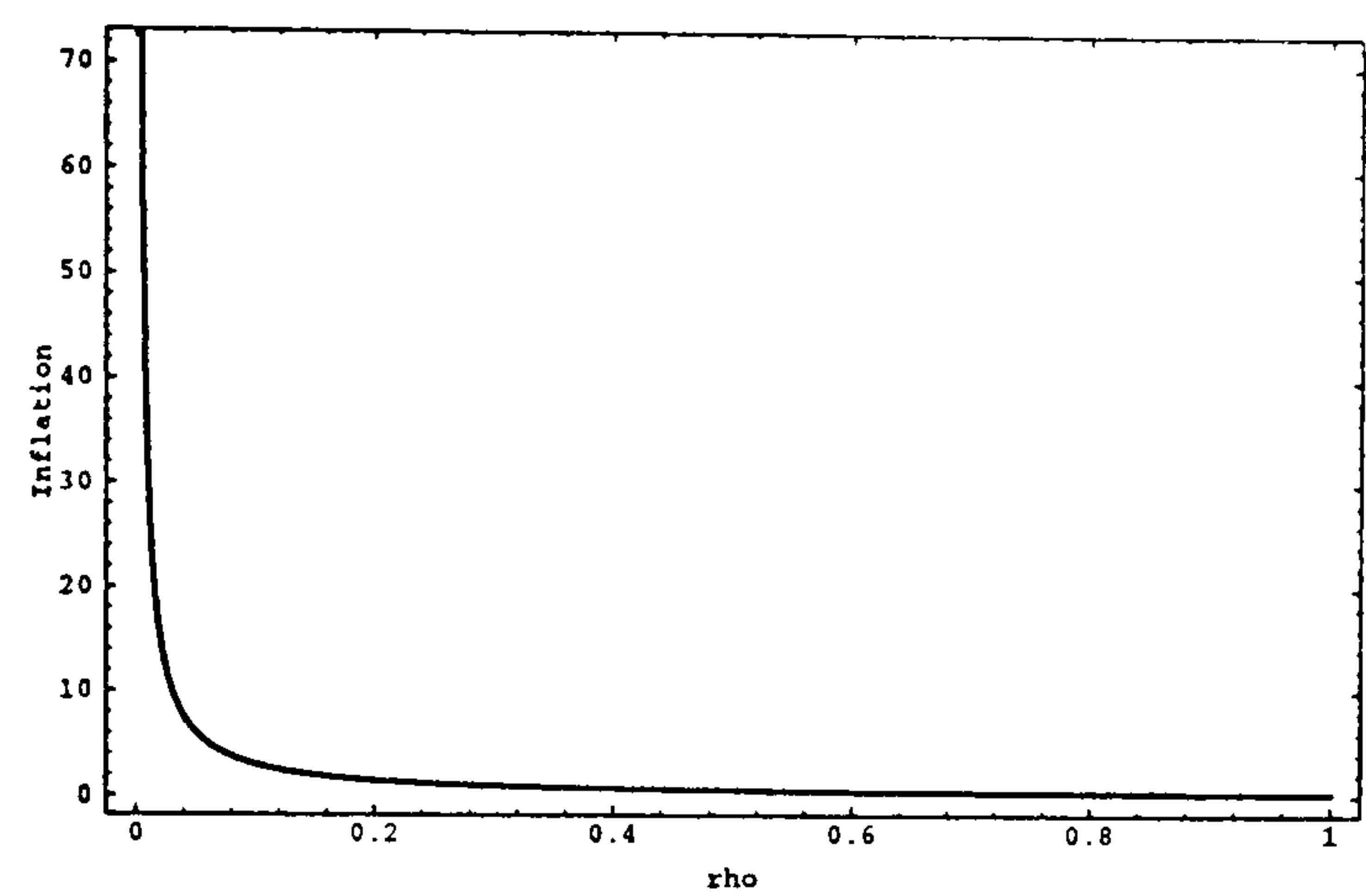
Second, for the two economies, the steady state level of inflation appears to respond in the same direction to changes in the parameters. Figure 5.1 illustrates how the inflationary bias decreases with  $\rho$ , the output elasticity of prices, for  $\delta = 0.95$ ,  $\lambda = 0.5$  and  $\tilde{y} = 0.3$ . The larger  $\rho$ , the more costly is a monetary surprise and, therefore, the smaller the incentive to inflate. Moreover, the inflationary bias decreases with  $\lambda$ , the monetary authority's concern about inflation. Figure 5.1 illustrates, for  $\delta = 0.95$ ,  $\tilde{y} = 0.3$  and  $\rho = 0.25$ , the point emphasised by Rogoff (1985a), that calling for a more conservative central banker will reduce the credibility problem. Also, the smaller  $\tilde{y}$ , the equilibrium output loss due to the labour market distortion, the smaller the inflation in the equilibrium.



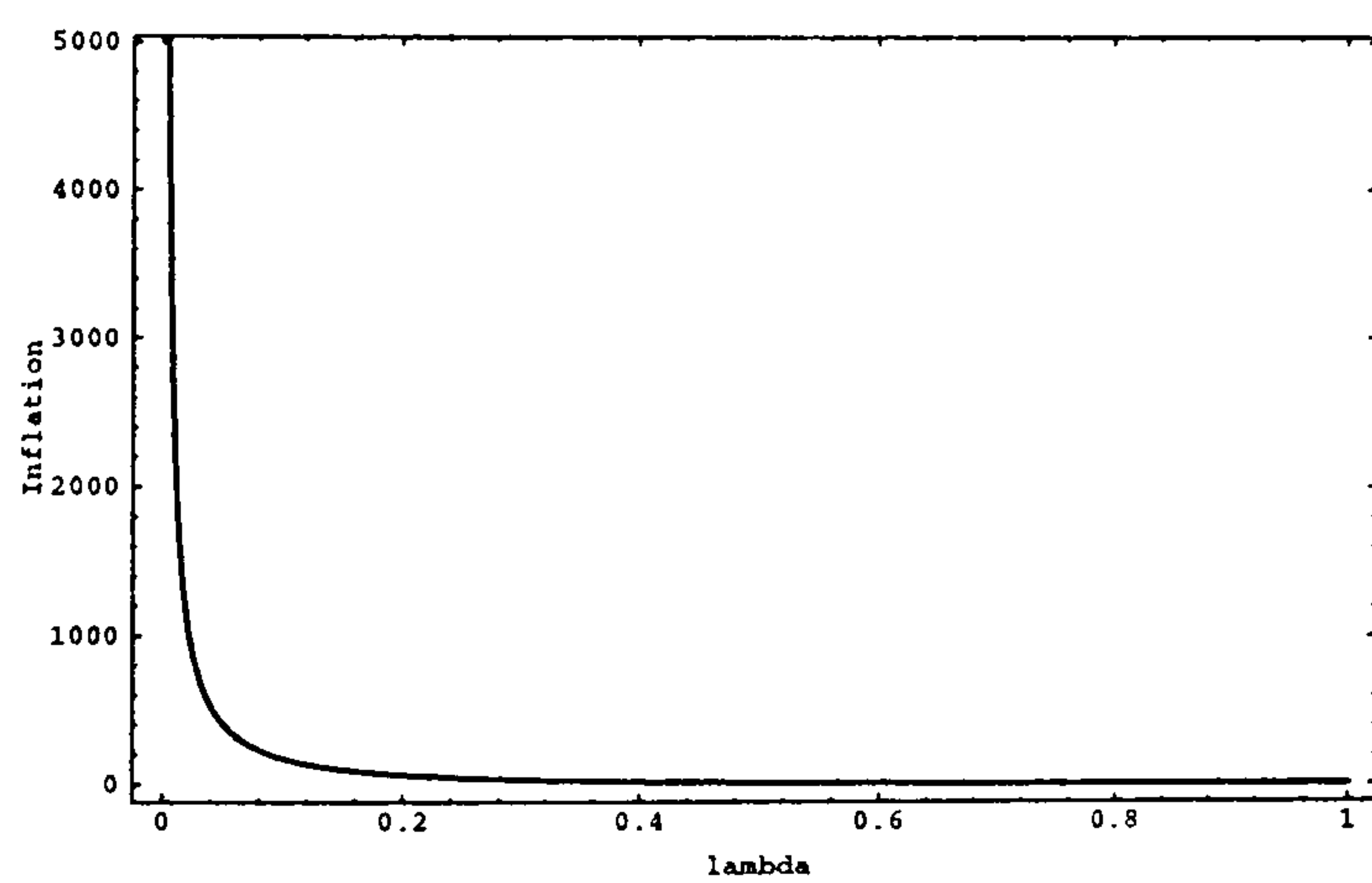
This is shown in Figure 5.2 for  $\delta = 0.95$ ,  $\lambda = 0.5$  and  $\rho = 0.25$ . Finally, for the staggered contract economy, expected inflation increases with  $\delta$ , the government's discount factor. This point is illustrated in Figure 5.2 for  $\lambda = 0.5$ ,  $\tilde{y} = 0.3$   $\rho = 0.25$ . Furthermore, the static and dynamic cases coincide for  $\delta = 0$ . As was the case in the presence of output persistence, the benefits of appointing a myopic central bank are overwhelming. A central bank, which does not care about the future, does not take into account the future benefits of expansionary policy either, so that the credibility problem faced by the monetary policy is heavily reduced.



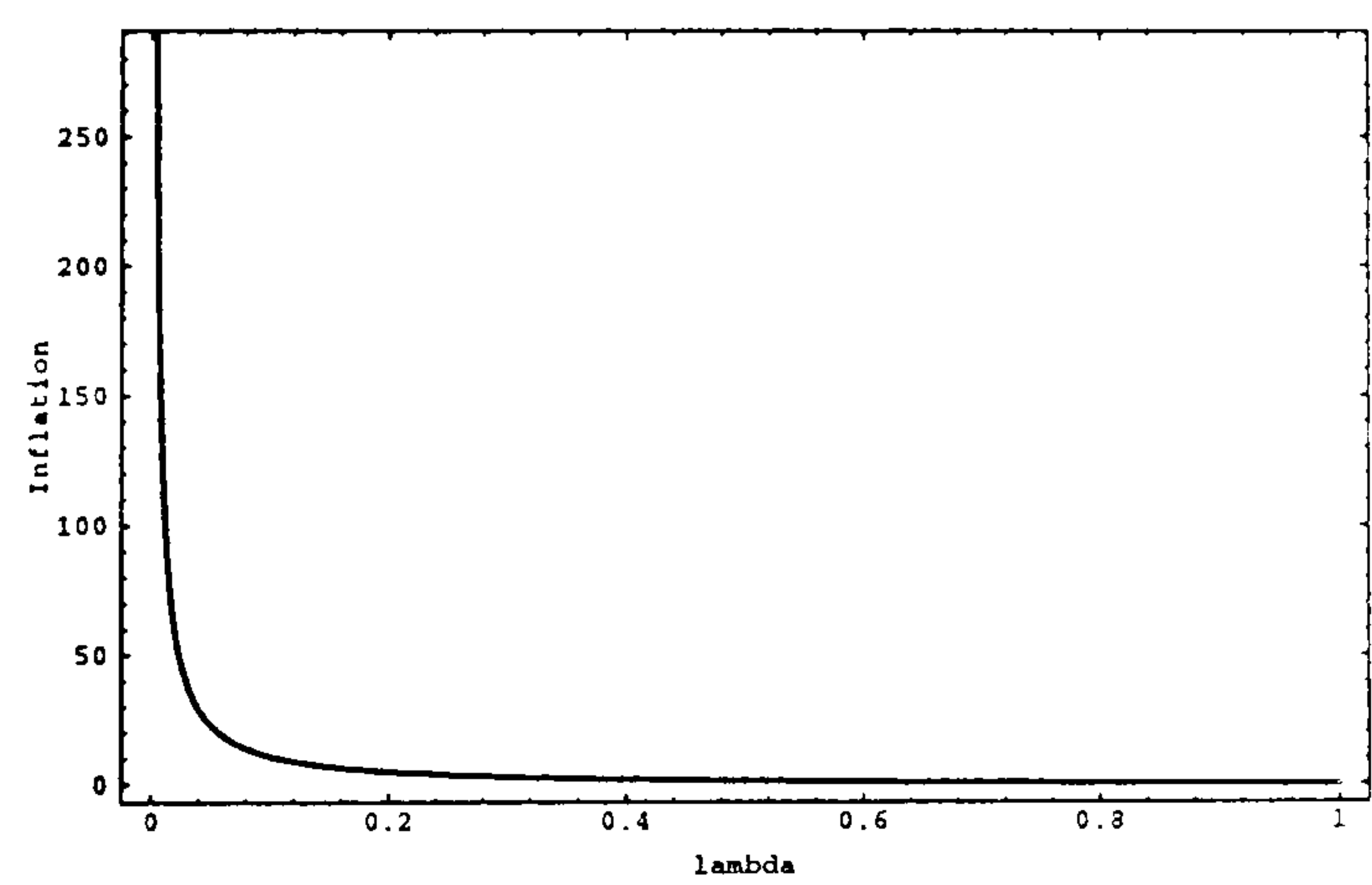
(a) Dynamic Case



(b) Static Case



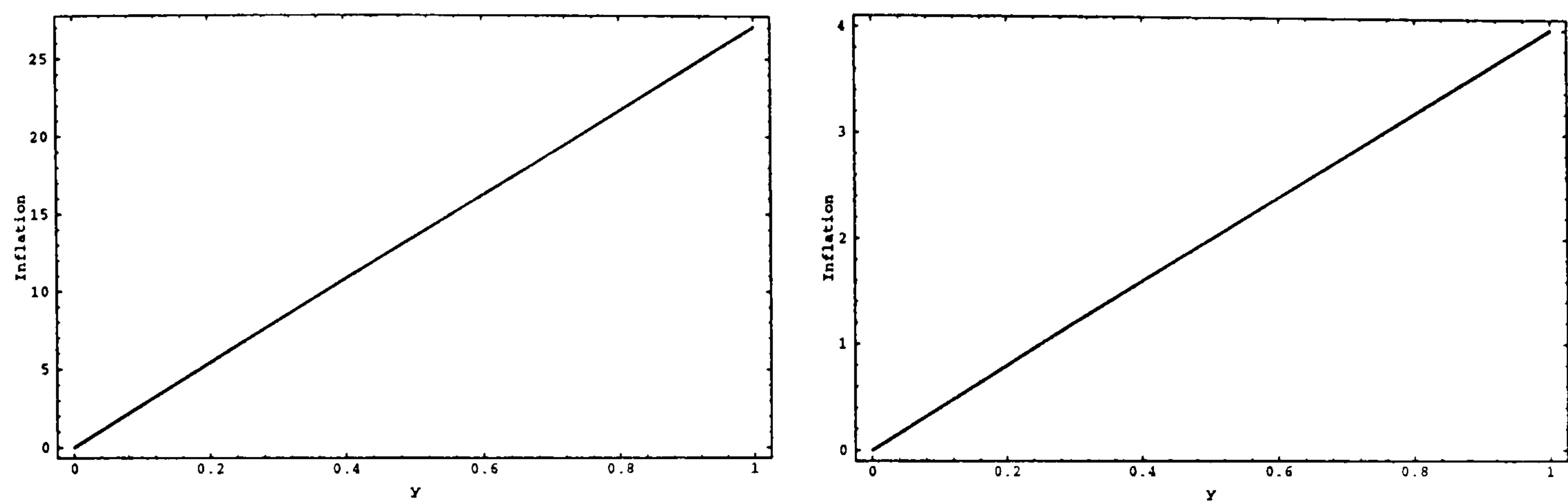
(c) Dynamic Case



(d) Static Case

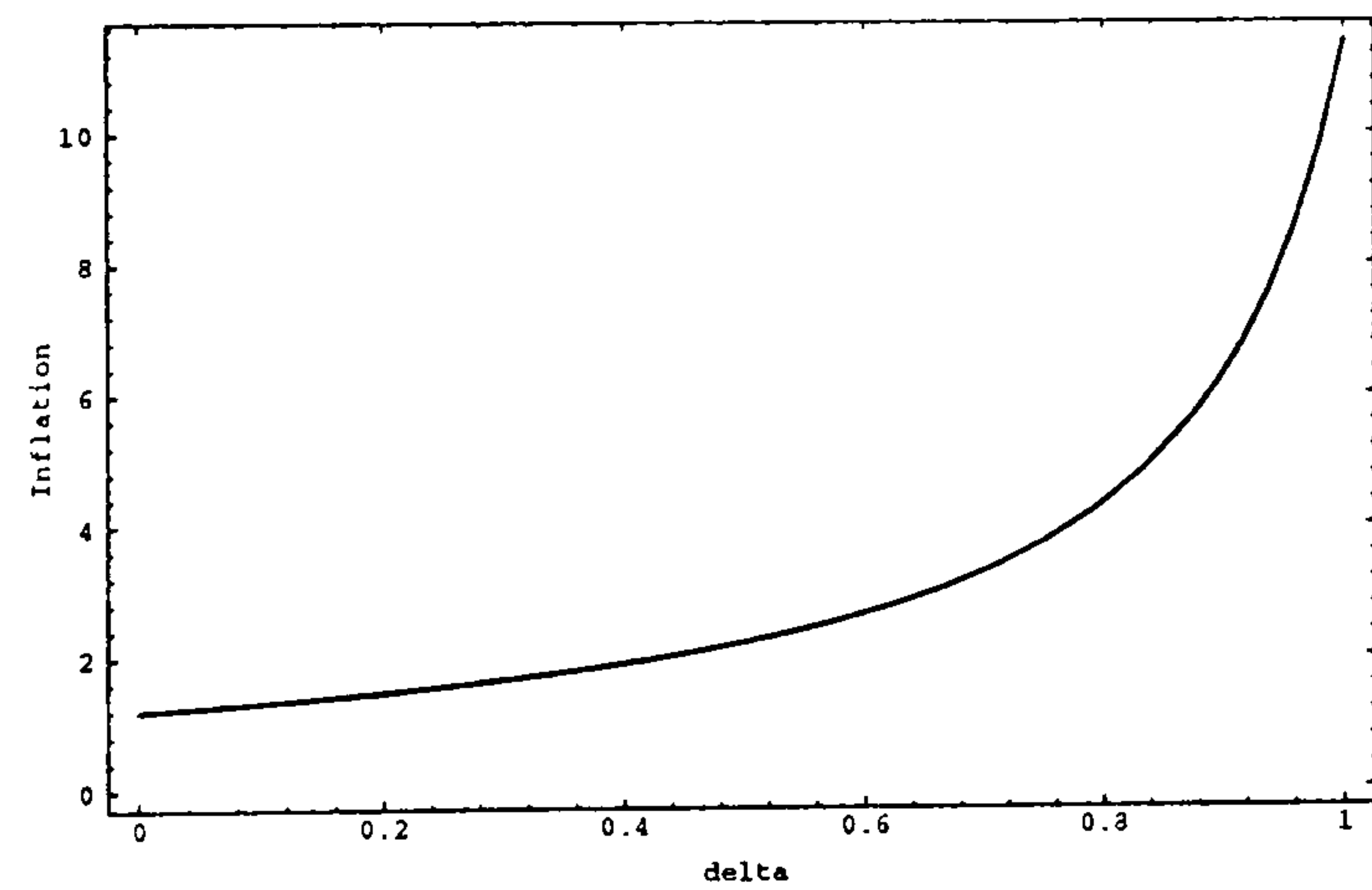
Figure 5.1: Inflationary Bias





(a) Dynamic Case

(b) Static Case



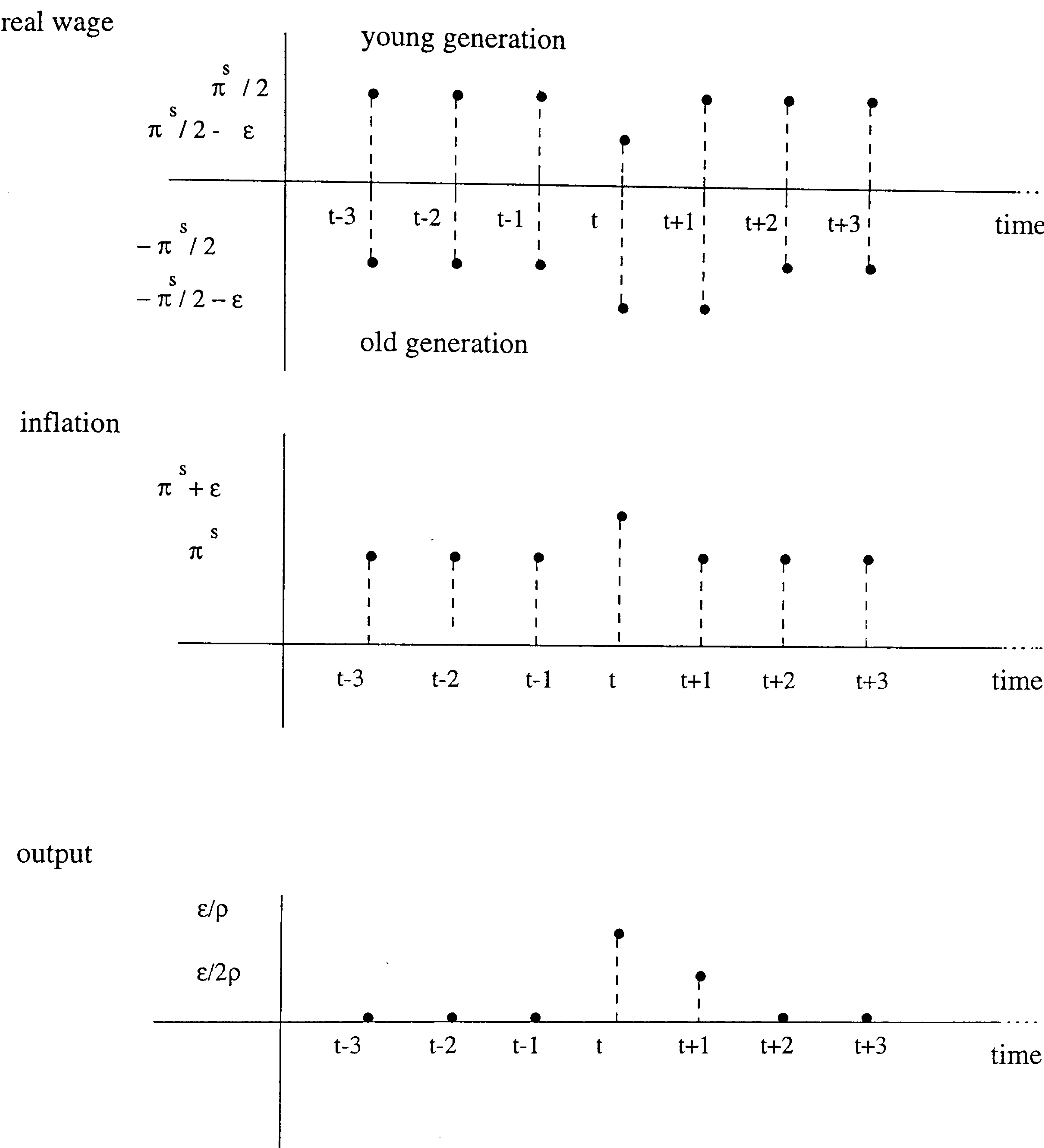
(c) Dynamic Case

Figure 5.2: Inflationary Bias

Third, the existence of multi-period contracts makes a difference when looking at the size of the inflationary bias. Where there are long-term staggered contracts, the losses in terms of inflation are extremely large. Though monetary policy has no permanent real effects, it does lead to temporary changes in output and employment. This can be explained as follows:

Suppose that we start off at the inflationary bias associated with the *static* (one period contract) equilibrium. We aim to show that, in the staggered-contract model, there is an incentive for the government to inflate beyond this point. At the *static* model's equilibrium, the level of expected inflation is such that there is no incentive for the government to inflate any further. By definition of the time consistent solution, the benefits of increasing demand in terms of increasing  $y_t$  are exactly offset by the increased inflation. However, in the staggered contract model, if wage setters anticipated the *static* equilibrium rate of inflation, a little extra inflation will be worth paying. At this point, it becomes necessary to explain one of the main characteristics of our model. Since we have assumed that our contracts last for two periods, our economy can be thought to be composed, at any point in time, of two cohorts, the young and the old. Furthermore, the wage contract fixes the nominal wage to be received for the next two periods, so that, for any equilibrium with positive inflation, the current old's real wage is below zero, while the young's is above. Therefore, if wage setters anticipate





$\epsilon$  = inflationary surprise

Figure 5.3: The effects of a monetary surprise at time  $t$

the *static* equilibrium rate of inflation,  $\pi^s$ , the real wage received by the workers will evolve as in Figure 5.3 below.

In the long-term staggered contracts economy, if wage setters anticipate the static equilibrium rate of inflation  $\pi^s$ , a small increase in  $y_t$ , due to a monetary expansion at time  $t$ , will represent a zero first-order loss at  $t$ . However, the monetary surprise at  $t$  implies that, during period  $t + 1$ , the old's real wage will be too low. If we went back to the *static* equilibrium rate of inflation,  $\pi^s$ , from  $t + 1$  onwards,  $y_{t+1}$  would be increased at effectively no cost (hence, a first-order gain). When nominal wages are fixed for two periods, the short-run incentive to inflate is not different from the *static* case. But, given that an inflation surprise at  $t$  will not only increase current output, but also next period output, the (present-value) benefit of inflation increases.<sup>9</sup>

Let us now refer to the equilibrium paths. The adjustment of  $z_t$  towards the equilibrium is given by Equation (5.21). This implies that, for any given initial inflation, our state variable immediately jumps to reach the unique rational expectations equilibrium. However, the dynamic paths for inflation,  $p_t - p_{t-1}$ , and output,  $y_t$ , are expressed in Equations (5.19) and (5.20), respectively,

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<sup>9</sup>A similar argument suggests that the inflation bias associated with the *static* case would not be sufficient to stop the government inflating in a model with long-term, time-varying contracts *à la* Fischer.

$$\begin{aligned}
 p_t - p_{t-1} = & 2A(1 - \lambda)\rho\tilde{y} - A\delta\rho^2\beta_1 \\
 & + \frac{\alpha_0}{1 + \rho} \left( \rho B + \frac{1}{2} \right) + \alpha_1 z_{t-1},
 \end{aligned}
 \tag{5.23}$$

and

$$\begin{aligned}
 y_t = & 2A(1 - \lambda)\tilde{y} - A\delta\rho\beta_1 \\
 & + \frac{\alpha_0}{1 + \rho} \left( B - \frac{1}{2} \right) + \left( \frac{\lambda\rho}{1 - \lambda + 2\lambda\rho^2} \right) z_{t-1}.
 \end{aligned}
 \tag{5.24}$$

Deviations of inflation and output from their long-run equilibrium rates respond to changes in  $z_{t-1}$  as expected.

### Departure from commitment

Suppose we start off at time  $t$  with the *second-best* policy, characterised by zero inflation and output at its natural rate ( $y_t = 0$ ).<sup>10</sup> This policy is optimal only *ex-ante* because, though the policy-maker would announce zero inflation before wage setters write their contracts, he would prefer to depart from its earlier commitment afterwards. These kinds of policies are also known as time inconsistent and cannot be implemented in the absence of precommitment.

Let us now assume that at time  $t + 1$  the government reneges on its commit-

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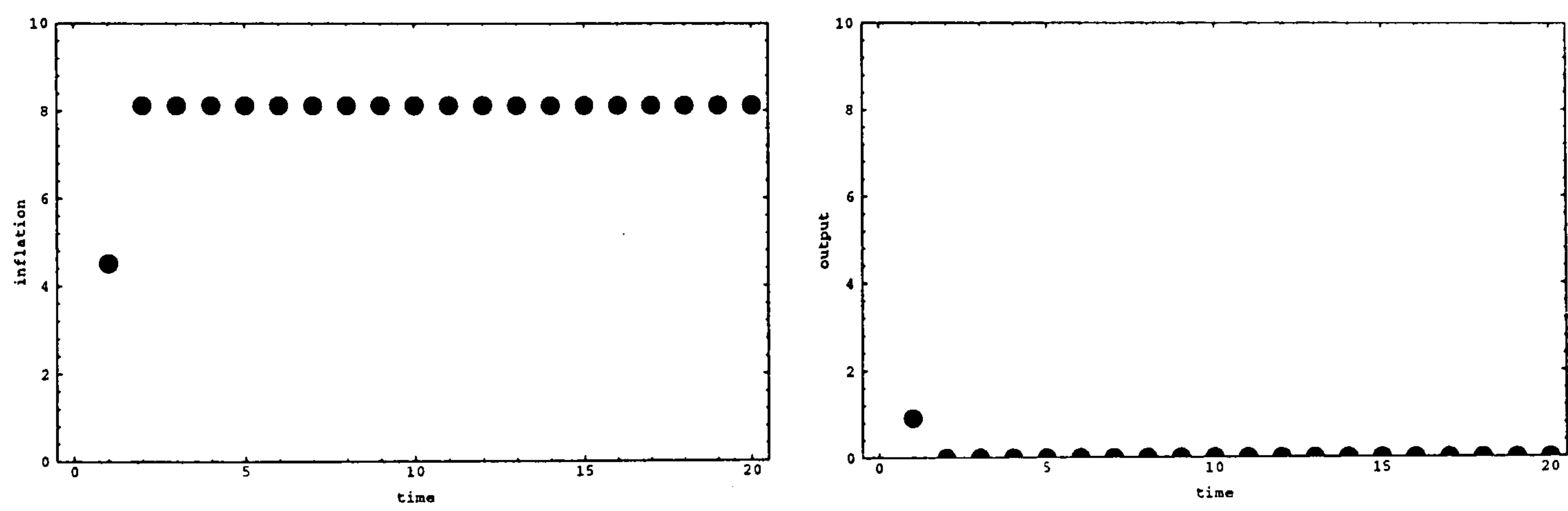
<sup>10</sup>Let us recall our definition of *first-best* policies as those aimed at eliminating the distortions tempting monetary policy makers to inflate.



ment and announces its intention of following a discretionary policy from now onwards. In a one period wage setting model this would imply an instantaneous jump to the unique discretionary equilibrium; but this is not the case in our context with staggered wage setting. Because at time  $t$  money remains constant as expected,  $x_t$  and  $x_{t-1}$  must be equal to the price level, so that  $z_t$  must equal zero. This implies, in turn, that, at time  $t$ ,  $z_t$  is larger than  $Z$ , so that the state variable jumps downwards to reach the unique equilibrium, where  $z_{t+1} = Z$ . As a result, the real wage received at period  $t + 1$  for those workers that are writing their contracts at period  $t + 1$  increases and inflation goes up. But, as the average real wage of the economy at period  $t + 1$  is smaller than zero, output jumps above its long-run equilibrium level. As a consequence, inflation and output increase. This can be illustrated with the Figure 5.4 below. The expansionary effects last only for one period. At period  $t + 2$ , the state variable  $z_{t+1}$  already equals  $Z$ , its long-run equilibrium level, and output, inflation and the average real wage reach their equilibrium values.

## 5.4 The Role for Precommitment

As pointed out in the previous section, a *second-best* solution would be to design a permanent constitutional reform that prescribes zero inflation but allows the central



(a) Inflation

(b) Output

Figure 5.4: Equilibrium Paths

bank to respond optimally to disturbances. There are some practical drawbacks, however, in legislating a fully state-contingent rule. For example, for the rule to be effective, it must be set in such a way that it is very difficult to change. This raises the danger that the policy-maker may be unable to foresee the nature of the shocks buffeting the economy many years in advance. Furthermore, the existence of transaction costs may make it prohibitively costly to specify the inflation rate to be chosen optimally in every possible state of nature.

In a deterministic framework – as in the one presented here – no monetary policy stabilisation is required; the optimal policy rule is easy to legislate, and a policy maker, who has a zero inflation bliss point, could perfectly deliver *sensible* monetary policy. Indeed, in the one period wage setting model – here also referred as the *static* economy – the precommitment to the *ex-ante* optimal monetary policy unambiguously provides us with the *second-best* solution. Precommitment solutions, however, appear to have different properties in the presence of staggered wage setting.

In this section we discuss the commitment solution for an economy with long-term staggered contracts. In particular, we look at two different scenarios. In the first one, the central bank announces the money supply only for the current period  $m_t$ . We show that, as the wage contracts last for two periods<sup>11</sup>, the monetary authority's

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<sup>11</sup>By a period it is meant the length of time between the decisions on monetary policy taken by the central bank.



precommitment to  $m_t$ , but not to  $m_{t+1}$ , is not enough to remove the inflation bias. Therefore, we also analyse the precommitment solution when the government is able to announce in advance the monetary policy that will be implemented for the same duration as nominal wage contracts. In other words, we allow the central bank to choose the money supply one period in advance, so that at the beginning of time  $t$  the central bank also makes the announcement for  $m_{t+1}$ . We show that, with this precommitment structure, the *second-best* solution, which provides zero inflation with no losses of output, is shown not to be *ex-ante* optimal. In other words, even before the wage setters write their contracts, at the beginning of time  $t$ , the policy-maker will generally prefer to announce a monetary policy,  $m_{t+1}$ , that does not deliver zero inflation.

Before turning to this discussion, we should emphasise, that we do not solve for a one-time commitment to *all future* money supplies, – commitment to  $\{m_{t+i}, i = 0, \dots, \infty\}$ , at the beginning of time  $t$ . One may argue that such a precommitment structure could be sufficient to solve the credibility problem described so far. This is, however, a possibility that we do not consider in this chapter. First of all, we believe that neither governments nor central bankers are able to precommit to the entire path of all future money supplies. Second, we do not observe such a precommitment structure in the real world.

### 5.4.1 Precommitment to $m_t$

The optimal rule under commitment to  $m_t$  is derived as the solution to the following problem:

$$V(z_{t-1}) = \underset{m_t}{\text{Min}} [(1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2 + \delta V(z_t)], \quad (5.25)$$

subject to

$$p_t = \frac{1}{1 + \rho} [\rho m_t + \frac{1}{2} (x_t + x_{t-1})], \quad (5.26)$$

$$y_t = \frac{1}{1 + \rho} [m_t - \frac{1}{2} (x_t + x_{t-1})], \quad (5.27)$$

$$x_t = \alpha_0' + \alpha_1' z_{t-1} + \alpha_2' (m_t - x_{t-1}) + p_{t-1}, \quad (5.28)$$

and  $z_t \equiv p_t - x_t$ .<sup>12</sup>

This problem differs from the discretionary solution in that  $m_t$  is already known when the wage setters are writing their contracts. Formally, the only difference from the previous model is that, within a period, the order of movements between the wage

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<sup>12</sup>From now on, the parameters  $\alpha_i'$  ( $\beta_i'$ ) denote the coefficients that characterise the equilibrium wage setters' reaction function (present discounted social losses) under commitment to  $m_t$ .

setters and the policy-maker has been reversed. Following the MPE restrictions, we propose a wage setters' reaction function that includes the new variable,  $(m_t - x_{t-1})$ , in order to capture all the relevant information available to wage setters at the time of writing their contracts. Note that the present discounted social losses from  $t$  onwards are still given by an equation of the form of (5.15), so that the optimal rule is given by a feedback rule for  $m_t$  on  $z_{t-1}$ . To obtain the first order condition to this problem, we shall resort to computer algebra. Hence, after running the *Mathematica* programme presented in Appendix B.3.1, we can write:

$$m_t = \frac{-J}{A} - \frac{K}{A} z_{t-1} + p_{t-1}, \quad (5.29)$$

$$y_t = \frac{-\alpha_0' + (2 - \alpha_2')(\frac{-J}{A})}{2(1 + \rho)} + \frac{1 - \alpha_1' - \alpha_2' + (2 - \alpha_2')(\frac{-K}{A})}{2(1 + \rho)} z_{t-1}, \quad (5.30)$$

$$p_t - p_{t-1} = \frac{\alpha_0' + (2\rho + \alpha_2')(\frac{-J}{A})}{2(1 + \rho)} + \frac{\alpha_1' + \alpha_2' - 1 + (2\rho + \alpha_2')(\frac{-K}{A})}{2(1 + \rho)} z_{t-1}, \quad (5.31)$$

$$\begin{aligned} z_t = & -\alpha_0' + \alpha_2' \left( \frac{J}{A} \right) + \frac{\alpha_0' + (2\rho + \alpha_2')(\frac{-J}{A})}{2(1 + \rho)} \\ & + \left[ \frac{\alpha_2' K}{A} - \alpha_1' - \alpha_2' + \frac{\alpha_1' + \alpha_2' - 1 + (2\rho + \alpha_2')(\frac{-K}{A})}{2(1 + \rho)} \right] z_{t-1}. \end{aligned} \quad (5.32)$$



Or alternatively,

$$m_t - x_{t-1} = \frac{-J}{A} - \left( \frac{K}{A} - 1 \right) z_{t-1}; \quad (5.33)$$

$$y_t = \frac{-\alpha_0'}{2(1+\rho)} + \left[ \frac{2 - \alpha_2'}{2(1+\rho)} \right] (m_t - x_{t-1}) - \left[ \frac{\alpha_1' + 1}{2(1+\rho)} \right] z_{t-1}, \quad (5.34)$$

$$p_t - p_{t-1} = \frac{\alpha_0'}{2(1+\rho)} + \left[ \frac{2\rho + \alpha_2'}{2(1+\rho)} \right] (m_t - x_{t-1}) + \left[ \frac{\alpha_1' - 1 - 2\rho}{2(1+\rho)} \right] z_{t-1}, \quad (5.35)$$

$$z_t = -\alpha_0' + \frac{\alpha_0'}{2(1+\rho)} + \left[ \frac{2\rho + \alpha_2'}{2(1+\rho)} - \alpha_2' \right] (m_t - x_{t-1}) + \left[ \frac{\alpha_1' - 1 - 2\rho}{2(1+\rho)} - \alpha_1' \right] z_{t-1}, \quad (5.36)$$

where

$$\begin{aligned} J = & -2\alpha_0' + \alpha_0'\alpha_2' - \alpha_2'\beta_1'\delta + \alpha_0'\alpha_2'\beta_2'\delta + 2\alpha_0'\lambda + 2\beta_1'\delta\rho - 3\alpha_2'\beta_1'\delta\rho - 2\alpha_0'\beta_2'\delta\rho \\ & + 4\alpha_0'\alpha_2'\beta_2'\delta\rho + 2\alpha_0'\lambda\rho + 2\beta_1'\delta\rho^2 - 2\alpha_2'\beta_1'\delta\rho^2 - 4\alpha_0'\beta_2'\delta\rho^2 + 4\alpha_0'\alpha_2'\beta_2'\delta\rho^2 \\ & - 4\tilde{y} + 2\alpha_2'\tilde{y} + 4\lambda\tilde{y} - 2\alpha_2'\lambda\tilde{y} - 4\rho\tilde{y} + 2\alpha_2'\rho\tilde{y} + 4\lambda\rho\tilde{y} - 2\alpha_2'\lambda\rho\tilde{y}, \end{aligned} \quad (5.37)$$

$$\begin{aligned}
A = & 4 - 4\alpha_2' + \alpha_2'^2 + \alpha_2'^2\beta_2'\delta - 4\lambda + 4\alpha_2'\lambda - 4\alpha_2'\beta_2'\delta\rho + 4\alpha_2'^2\beta_2'\delta\rho \\
& + 4\alpha_2'\lambda\rho + 4\beta_2'\delta\rho^2 - 8\alpha_2'\beta_2'\delta\rho^2 + 4\alpha_2'^2\beta_2'\delta\rho^2 + 4\lambda\rho^2,
\end{aligned} \tag{5.38}$$

$$\begin{aligned}
K = & 2 - 2\alpha_1' - 3\alpha_2' + \alpha_1'\alpha_2' + \alpha_2'^2 + \alpha_2'\beta_2'\delta + \alpha_1'\alpha_2'\beta_2'\delta + \alpha_2'^2\beta_2'\delta - 2\lambda + 2\alpha_1'\lambda \\
& + 2\alpha_2'\lambda - 2\beta_2'\delta\rho - 2\alpha_1'\beta_2'\delta\rho + 4\alpha_1'\alpha_2'\beta_2'\delta\rho + 4\alpha_2'^2\beta_2'\delta\rho - 2\lambda\rho + 2\alpha_1'\lambda\rho \\
& + 2\alpha_2'\lambda\rho - 4\alpha_1'\beta_2'\delta\rho^2 - 4\alpha_2'\beta_2'\delta\rho^2 + 4\alpha_1'\alpha_2'\beta_2'\delta\rho^2 + 4\alpha_2'^2\beta_2'\delta\rho^2.
\end{aligned} \tag{5.39}$$

In order to characterise the solution to our problem we need to identify the parameters  $\alpha_0'$ ,  $\alpha_1'$ ,  $\alpha_2'$ ,  $\beta_1'$ , and  $\beta_2'$ . With respect to  $\alpha_0'$  and  $\alpha_1'$ , the coefficients in Equation (5.28) must be equal to those obtained after substituting Equation (5.35) into (??). Furthermore, we must replace the expressions (5.30) and (5.31) into (5.12) and ensure that the coefficients on  $z_{t-1}$  are identical to those of Equation (5.15).

Looking at the expression for  $z_t$ , after substituting out the values for  $\alpha_0'$ ,  $\alpha_1'$  and  $\alpha_2'$ , presented in Appendix B.3.2, we can write:

$$z_t = \frac{-(1-\lambda)\tilde{y}}{4\lambda\rho}. \tag{5.40}$$

Our solution for the state variable mirrors that obtained in the dynamically consistent equilibrium, in the sense that the state variable is always at its unique rational expectations equilibrium level. Therefore, Equation (5.40) gives us the steady state value for  $z_t$ , which, in turn, implies a steady state inflationary bias of:

$$\bar{k} = \frac{(1 - \lambda)\tilde{y}}{2\lambda\rho}. \quad (5.41)$$

With respect to the equilibrium level of output, this remains at the natural rate, i.e.,  $y = 0$ .

A comparison between Equations (5.41) and (5.6) enables us to conclude what we had already suggested. The equilibrium inflation rate equals half the inflation bias associated to the *static* case. The reason for this is pretty intuitive: In any moment of time  $t$ , half of the wage contracts will not be revised, and the government has an incentive to exploit the output benefits derived from surprise inflation. Wage setters anticipate this temptation and increase their wage contracts so as to prevent any monetary surprise.<sup>13</sup> In the presence of long-term staggered contracts, in order to remove completely the inflation bias, the government should be able to precommit for as many periods as periods last the wage contracts. We turn to this matter in the next subsection.

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<sup>13</sup>One might think that this structure of precommitment could be sufficient to remove the current inflationary bias in the presence of long-term, time-varying contracts *à la* Fischer. If wage contracts last for more than one period, however, precommitment to  $m_t$  only will not be sufficient to avoid the incorporation of positive expected inflation in the future.



### 5.4.2 Precommitment to $m_{t+1}$

In this section, we analyse the precommitment solution when the government is able to announce in advance the monetary policy that will be implemented for the whole duration of the contract written at  $t-1$ . In other words, before the wage contracts are written, at the beginning of period  $t-1$ , the government announces  $m_{t-1}$  and  $m_t$ . It should be noted that the government cannot follow this structure of precommitment for more than one period: when time  $t$  arrives,  $m_t$  has been already determined by the previous announcement, and all that is left is the announcement of the monetary policy for next period,  $m_{t+1}$ . This will lead to a sort of sequence of overlapping monetary decisions.

The optimal rule under commitment to  $m_{t+1}$  is derived as the solution to the following problem:

$$V(z_{t-1}, m_t - x_{t-1}) = \underset{m_{t+1}}{\text{Min}} \left[ (1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2 + \delta V(z_t, m_{t+1} - x_t) \right], \quad (5.42)$$

subject to

$$p_t = \frac{1}{1 + \rho} \left[ \rho m_t + \frac{1}{2} (x_t + x_{t-1}) \right], \quad (5.43)$$

$$y_t = \frac{1}{1+\rho} \left[ m_t - \frac{1}{2} (x_t + x_{t-1}) \right], \quad (5.44)$$

$$x_t = \alpha_0'' + \alpha_1''(m_t - x_{t-1}) + \alpha_2''(m_{t+1} - x_{t-1}) + x_{t-1}, \quad (5.45)$$

and  $z_t \equiv p_t - x_t$ .<sup>14</sup>

In this case, the wage setters know both  $m_t$  and  $m_{t+1}$  at the time of writing their contracts. Following the MPE restrictions, we propose a wage setters' reaction function that includes the new state variable  $(m_t - x_{t-1})$ , and also  $(m_{t+1} - x_{t-1})$  as the workers make use of all relevant information available when the contracts are written at the beginning of period  $t$ . With respect to the present discounted value of social losses, the reaction function given by Equation (5.15) has to be rewritten to look like

$$\begin{aligned} V(z_{t-1}, m_t - x_{t-1}) = & \beta_0'' + \beta_1'' z_{t-1} + \beta_2'' (m_t - x_{t-1}) \\ & + \beta_3'' z_{t-1} (m_t - x_{t-1}) + \beta_4'' z_{t-1}^2 + \beta_5'' (m_t - x_{t-1})^2. \end{aligned} \quad (5.46)$$

As argued in Section 5.3, a more general value function for the policy maker,  $V(p_{t-1}, x_{t-1}, m_t)$ , could have been proposed. We will show, however, that there exists a solution to our problem in which  $p_{t-1}, x_{t-1}, m_t$  enter the policy maker's value function in the way proposed here.

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<sup>14</sup>From now onwards, the parameters  $\alpha_i''$  ( $\beta_i''$ ) denote the coefficients that characterise the equilibrium wage setters' reaction function (present discounted social losses) under commitment to  $m_{t+1}$ .

The model is solved, once again, with the help of *Mathematica*.<sup>15</sup> In this case, we cannot obtain a general solution for the equilibrium inflation rate, but we do get some economic intuition through the numerical simulations presented in Table 5.1.<sup>16</sup>

Table 5.1: Inflation in the steady state

|                        | $\pi$  |
|------------------------|--------|
| $\delta = .95$         | .01441 |
| $\delta = .5$          | .06    |
| $\delta = \frac{1}{3}$ | 0      |
| $\delta = 0$           | -.03   |

Other values  $\rho = .25$ ,  $\lambda = .5$ , and  $\tilde{y} = .03$ .

|                 | $\pi$  |
|-----------------|--------|
| $\lambda = 1$   | 0      |
| $\lambda = .8$  | .0041  |
| $\lambda = .05$ | .01805 |

Other values  $\rho = .25$ ,  $\delta = .95$ , and  $\tilde{y} = .03$ .

|              | $\pi$ |
|--------------|-------|
| $\rho = 1.5$ | .0011 |
| $\rho = .75$ | .0033 |
| $\rho = .05$ | .0867 |

Other values  $\delta = .95$ ,  $\lambda = .5$ , and  $\tilde{y} = .03$ .

|                   | $\pi$ |
|-------------------|-------|
| $\tilde{y} = 1$   | .4805 |
| $\tilde{y} = .05$ | .024  |
| $\tilde{y} = 0$   | 0     |

Other values  $\rho = .25$ ,  $\lambda = .5$ , and  $\delta = .95$ .

If the government does not suffer from a credibility problem, either because it is only concerned about inflation, ( $\lambda = 1$ ), or because it lacks the incentives to create monetary surprises, ( $\tilde{y} = 0$ ), the equilibrium inflation rate equals zero. However, when the parameter  $\lambda$  is not equal to 1 or when  $\tilde{y}$  is different from zero, the long-run level of inflation does not correspond to zero. In these cases the value of society's discount factor seems to play an important role.

<sup>15</sup>Since we assume that  $V_t(z_{t-1}, m_t - x_{t-1})$  is linear quadratic in  $z_{t-1}$  and  $(m_t - x_{t-1})$ , the optimal monetary rule can be written as a linear feedback rule for  $m_{t+1}$  on  $z_{t-1}$  and  $(m_t - x_{t-1})$ .

<sup>16</sup>Some infinite horizon monetary policy games, based on MPE, have been shown to possess a multiplicity of Perfect Nash Equilibria, see, e.g., Lockwood and Philippopoulos (1994). Our simulations suggest that this is also the case for this example. The results presented in this subsection correspond to the most intuitive equilibrium.



For example, assuming that we start off at zero inflation, a very impatient monetary authority would choose to announce future cuts in the growth of money, so as to induce a short-run increase in current output. In other words, a monetary institution that heavily discounted the future would choose to announce, at the beginning of time  $t$ , a contractionary monetary policy for  $t+1$ . In extreme cases, when the policy-maker is very *myopic*, a deflationary policy would be announced. Our simulations show that a negative steady state inflation rate might well exist for small values of  $\delta$ .

The intuition is clear: at time  $t$ ,  $m_t$  has been already determined by, let us say, a previous government committed to zero inflation, i.e.,  $m_t = m_{t-1} = p_{t-1}$ . The announcement of a decrease in the growth of money for tomorrow,  $m_{t+1} - m_t < 0$ , leads to a disinflationary process, for labour market equilibrium to be preserved at  $t+1$ .<sup>17</sup> As a result, wages written at the beginning of time  $t$ ,  $x_t$ , will not be as high as expected at time  $t-1$ , when  $x_{t-1}$  and  $m_t$  were chosen. Therefore, the current level of prices,  $p_t$ , will be smaller than expected at  $t-1$ . But, if  $p_t < p_{t-1} = m_t$ ,  $m_t$  will be too large and there will be gains in terms of current output.

Similar scenarios for costless, credible disinflations, which occur without any increase in unemployment, can be found in the literature. In Taylor (1983) credible disinflation can be costless, but only if it is slow, in a model with precommitment

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<sup>17</sup>Note that, in this particular example, *disinflation* (decrease in the growth rate of prices) effectively means *deflation* (decrease in the price level), since we are assuming a zero inflation starting point at time  $t$ .

and time-varying wage contracts. Buiter and Miller (1985) use Calvo (1983) model of staggering to show that immediate disinflation is costless. The closest example to our analysis is provided by Ball (1994), who finds that fully credible disinflation will cause a *boom* in a model *à la* Taylor. Our analysis, however, departs from these works in two important respects. First, trying to explain whether the inflationary inertia arising from the staggered timing of price adjustments can be blamed for the costs of disinflationary policy, these authors assume perfect credibility from the side of the policy-maker. In our model, however, disinflationary policy is not assumed to be credible but it is shown to be the optimal and, therefore, credible choice of a very impatient policy-maker. Second, our model predicts that, for a very impatient central banker, not only disinflationary policy but also a deflationary one may be optimal and credible.

A very different picture is obtained when society is relatively more patient – values of  $\delta$  close to 1, as the long-run equilibrium is inflationary. We do not have a good intuition for this result, but we provide the following theory: In our model, even although the government announces what tomorrow's money supply,  $m_{t+1}$ , is going to be, it is unable to precommit to the level of prices,  $p_{t+1}$ . But, when wage setters try to target the equilibrium real wage, they are concerned over the value of  $p_{t+1}$ . Yet,  $p_{t+1}$  is a function of  $x_{t+1}$ . But  $x_{t+1}$  depends upon  $m_{t+2}$ , which is not determined at the time of writing the contracts at the beginning of time  $t$ . Wage setters may believe



that, if the policy-maker is known to care about the future, he might depart from the future from the zero inflation rule. So, under staggering, even if we allow the government to precommit itself for the two periods that the contracts last, it may be unable to solve the time inconsistency problem of monetary policy.<sup>18</sup>

Finally, the benefits of delegating the monetary policy to a central banker with the appropriate discount factor are clear: in our numerical simulations, if  $\delta$  was equal to  $1/3$ , the zero inflation rule could be easily achieved, when  $\rho = 0.25$ ,  $\lambda = 0.5$  and  $\tilde{y} = 0.03$ . Moreover, the delegation of the monetary policy to a policy-maker without any concern over output,  $\lambda = 1$ , or the elimination of the distortions tempting the policy-maker to inflate,  $\tilde{y} = 0$ , will also deliver a zero inflation rule.

## 5.5 Conservative central bankers

The results of the previous section indicate that the presence of long-term staggered contracts increases the credibility problem of monetary policy. In the light shed by that finding, one may argue that appointing a central bank more conservative than society will lead to a higher social welfare. This would be easy to achieve in our non stochastic framework. If the banker were solely concerned with inflation, i.e., if

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<sup>18</sup>Our intuition suggests that this result may not be translated to an economy with long-term, time-varying contracts. If this was the case, the need for a long term precommitment should be emphasised.



$\lambda = 1$ , zero inflation would be delivered.<sup>19</sup> Things will be different, however, in a stochastic model where the appointment of a more conservative central bank imposes a short-run trade off between low inflation and output stabilisation. Furthermore, as shown by Fischer (1977) and Taylor (1979, 1980), under long term contracts, a role for an active monetary stabilisation policy, even when completely anticipated, emerges. Monetary policy can offset the variability of output arising from economic disturbances that were not known at the time of setting the wages. Therefore, in economies characterised by staggered wage setting, the government would like to maintain the instruments to accommodate large shocks to output.

Levine and Pearlman (1994) obtain the optimal choice of a conservative banker for a staggered wage contract economy in the spirit of Calvo (1983). They find that, as nominal wage stickiness increases, optimal delegation of monetary policy requires a more conservative central bank. The reason for this is that nominal wage stickiness increases the present value benefits of monetary surprises, so that the government finds it more difficult not to inflate. In turn, this implies that a more conservative central bank needs to be appointed to achieve a given level of inflation. This result – recall also the literature on *hysteresis* – is particularly inefficient. In a context where monetary policy stabilisation is strongly desirable, the classical dilemma that characterises monetary policy-making provides control of inflation only at the cost of

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<sup>19</sup>This can be easily shown in Equation (??). Note that  $\beta_1$ ,  $\alpha_1$  and  $\alpha_0$  equal zero for  $\lambda = 1$ .

much less than optimal stabilisation.

## 5.6 Conclusions

What we show in this chapter is how the credibility problem of monetary policy acquires special significance in the presence of staggered wage setting. Moreover, some of the solutions proposed in the literature to overcome this problem, such as delegation or precommitment, appear to be less efficient when the extensive use of overlapping contracts is accounted for. There are several reasons:

Taylor (1980) demonstrates that, under staggered wage setting, one-time shocks to the economy are capable to generate unemployment persistence. We have already discussed, earlier in this thesis, how the persistence in unemployment increases the costs of delegating monetary policy to a very conservative central bank. Conservative central bankers are a *reasonably good, third-best* solution in a model *à la* Rogoff, but they seem not to perform so well for economies with distorted labour markets.

Precommitment to the *ex-ante* optimal monetary policy (*second-best*) though difficult to implement in a stochastic environment, would eliminate the inflationary bias of non credible monetary policy in a model with one period wage setting. Yet, allowing for nominal rigidities seriously reduces the efficiency of this mechanism. As shown before, period by period precommitment is not sufficient to reach the *second-best* so-



lution, if wage setters write their contracts for more than one period. If monetary decisions are taken at the beginning of each period, when, let us say, workers are setting contracts for two periods, at the beginning of every second period, then, the central banker will face credibility problems if committed only period by period. This result is also relevant to the literature on optimal inflation contracts for the central bank, for it emphasises the need for the sufficient length of such incentive contracts.

Finally, trying to solve this difficulty, a long-term but still feasible commitment has been proposed. Our findings suggest that, in the presence of long-term staggered wage contracts, a monetary authority, if sufficiently impatient, will not necessarily deliver zero inflation.



## Chapter 6

# The consequences of near-rational behaviour

### 6.1 Introduction

In most of the Keynesian models of the 1970's and early 1980's nominal rigidities were assumed rather than explained. However, in most cases, it was clearly in the interest of agents to eliminate the rigidities they were assumed to create. Fortunately, Keynesian economics has made much progress in the past few years, producing models in which optimising agents choose to create nominal rigidities.

Transaction costs and costs of negotiation involved in the wage – and price – setting process have been recognised, so that nominal wage contracts – and prices –

which fix the nominal wage – and price – for a period are usually readily accepted.

A different source of nominal rigidities leads us to the mechanism controlling the expectation formation process. Rational expectations – *versus* adaptive expectations – became increasingly attractive due to the important efforts undertaken after the Lucas' revolution in both empirical and theoretical basis.

According to rational expectations theorists, when economic agents take decisions they make efficient use of all the information available to them. Given that today there is limitless economic information available to the public, any attempt by the monetary authority to affect real economic activity will be futile. But recently an important number of economists have managed to embody in relatively sophisticated models what seems to be a much more appealing approach to reality: Rational people make good evaluations about the state of the economy, but they do not make continuous use of every single piece of information they can possibly obtain; that is, they are near-rational. Though near-rational behaviour does not make a great difference to single agents, the aggregate outcome may be very surprising. In particular, departures from fully rational behaviour can lead to real effects of nominal money and large output effects.<sup>1</sup>

In this chapter we show how the introduction of microfoundations, which explain

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<sup>1</sup>See Akerlof and Yellen (1985).

the nominal rigidities assumed in the literature, adds significantly to monetary policy games. We show that, when near-rational behaviour is considered, the time consistency problem of monetary policy acquires different relevance. Section 6.2 presents the model, borrowed from Akerlof and Yellen (1985), on which our analysis is based. With less than fully rational behaviour, monetary surprises lead to large output effects. Positive monetary shocks tend to expand the economy in the short-run, but disinflationary policy is too costly. Section 6.3 simply extends the original model to introduce the alleged credibility problem suffered by the monetary authority. As a result, the non-existence of an equilibrium in pure strategies is shown. Section 6.4 concludes.

## 6.2 The Akerlof and Yellen model

Let us consider an economy with only two different types of monopolistic firms. A fraction  $(1 - \beta)$  of all firms – the fully maximising firms – choose their prices and wages at the level that maximises profits, taking as given the average price level, i.e. assuming that its decision does not affect that of its competitors. The remaining fraction  $\beta$  – the non-maximising firms – sets its price and wage according to a rule of thumb in the short-run.



A downward-sloping demand curve for each firm is given by

$$Y = \left( \frac{M}{\bar{p}} \right) \left( \frac{p}{\bar{p}} \right)^{-\eta} \quad \eta > 1, \quad (6.1)$$

where  $Y$  denotes output of the firm,  $p$  the price being charged by the firm, and  $\bar{p}$  the general level of prices, defined as a geometric mean of prices.  $M$  denotes the money supply per firm<sup>2</sup>,  $\eta$  is the price elasticity of demand and  $\eta > 1$  implies that each firm has increasing revenues as its own price falls.

The production function of the firm equals

$$Y = (eN)^\alpha \quad 0 < \alpha < 1 \quad (6.2)$$

where  $e$  captures the average effort of workers and is assumed to depend upon the real wage paid by the firm:  $e = e(w)$ .  $e = e(w)$  is assumed to be a differentiable, concave function, whose elasticity with respect to  $w$  is less than one at high  $w$  and greater than one at low  $w$ .  $N$  denotes the level of employment in the firm.  $\alpha$  is the elasticity of the production function with respect to total units of effort within the firm, so that  $1/\alpha$  is the elasticity of marginal cost with respect to output.

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<sup>2</sup>Blanchard and Kiyotaki (1987) and Blanchard and Fischer (1989) demonstrate how a demand function for an individual firm, with real money supply and the firm's relative price as arguments, can be derived when consumers maximise an utility function which contains real money balances.

Nominal profits for the firm are given by

$$\Pi = p \left( \frac{M}{\bar{p}} \right) \left( \frac{p}{\bar{p}} \right)^{-\eta} - \left( \frac{M}{\bar{p}} \right)^{1/\alpha} \left( \frac{p}{\bar{p}} \right)^{-\eta/\alpha} \frac{w\bar{p}}{e(w)}. \quad (6.3)$$

In the long-run equilibrium, i.e., under the perfect information hypothesis, both types of firms charge the same price  $p = \bar{p}$ . Each firm chooses its price and wage in order to maximise profits, taking the average price level  $\bar{p}$  as given. For notational convenience, let us denote the variables in the initial period as follows:

$M_0$  as the initial money supply per firm,

$p_0$  as the average price, the price of maximising and non-maximising firms and

$w_0$  as the average real wage, the real wage of maximising and non-maximising firms.

Thus, the first order condition for profit maximisation implies

(i) First, with respect to prices,

$$\frac{\partial \Pi}{\partial p} = (1 - \eta) \left( \frac{M}{\bar{p}} \right) \left( \frac{p}{\bar{p}} \right)^{-\eta} + \frac{\eta}{\alpha} \left( \frac{M}{\bar{p}} \right)^{1/\alpha} \left( \frac{p^{-\eta/\alpha-1}}{\bar{p}^{-\eta/\alpha}} \right) \frac{w\bar{p}}{e(w)} = 0. \quad (6.4)$$

Evaluated at the initial equilibrium, where  $p = \bar{p} = p_0$ ,  $w = \bar{w} = w_0$  and

$M = M_0$ , one can write

$$(\eta - 1) \left( \frac{M_0}{p_0} \right) = \frac{\eta}{\alpha} \left( \frac{M_0}{p_0} \right)^{1/\alpha} \frac{w_0}{e(w_0)}, \quad (6.5)$$

so that

$$\left( \frac{M_0}{p_0} \right) = \left[ \frac{1}{\eta - 1} \frac{\eta}{\alpha} \frac{w_0}{e(w_0)} \right]^{\alpha/(\alpha-1)}. \quad (6.6)$$

Or, alternatively,

$$p_0 = kM_0, \quad k = \left[ \frac{1}{\eta - 1} \frac{\eta}{\alpha} \frac{w_0}{e(w_0)} \right]^{\alpha/(1-\alpha)}. \quad (6.7)$$

- (ii) Furthermore, given that a unit of real wage provides  $e$  units of effort, profit maximisation also implies, with respect to wages,

$$\text{Min} \left[ \frac{w_0}{e(w_0)} \right] \Rightarrow \frac{\partial e(w^*)}{\partial w} \frac{w^*}{e(w^*)} = 1, \quad (6.8)$$

i.e., profit maximisation implies that the firm chooses the real wage that minimises the unit cost of a labour efficiency unit. The real wage is chosen at the optimal level  $w^*$  where the elasticity of effort with respect to real wage is unity. In other words, the firm is paying the *efficiency wage*<sup>3</sup> and the first order

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<sup>3</sup>See Yellen (1984) and Shapiro and Stiglitz (1984) as examples for efficiency wage models.



condition needs to be written as

$$p_0 = k^* M_0, \quad k^* = \left[ \frac{1}{\eta - 1} \frac{\eta}{\alpha} \frac{w^*}{e(w^*)} \right]^{\alpha/(1-\alpha)} \quad (6.9)$$

With this choice of real wage  $w^*$ , the firm's labour demand is given by

$$N_0 = \frac{k^{*-1/\alpha}}{e(w^*)} \quad (6.10)$$

If the productivity of labour is assumed to depend on the real wage that workers received, this may induce firms to set wages above the market-clearing equilibrium level and involuntary unemployment will occur. Hence, we can assume that total supply for labour per firm exceeds total labour demand, so that there will be unemployment and the firm will obtain as much labour as it wants at its preferred real wage  $w^*$ .

This characterisation of the initial (long-run) equilibrium provides Akerlof and Yellen (1985) with the benchmark to discuss how much employment will change if there is a monetary surprise when some of the firms are not fully maximisers in the short-run.

If the money supply changes by a very small fraction  $\epsilon$ , so that  $M = M_0 (1 + \epsilon)$ , the short-run equilibrium will be characterised as follows. The short-run maximising

firms, whose variables will be denoted by an  $m$  superscript, set both price and wage at those levels that exactly maximise profits. The non-maximising firms follow a rule of thumb and continue to charge the same price for output and to pay the same money wage as in the original equilibrium. Variables for those firms are denoted by an  $nm$  superscript.

Thus, at the short-run equilibrium,

$$p^{nm} = p_0. \quad (6.11)$$

Furthermore, short-run profit maximisation with respect to wages implies that  $w^m$  must remain unchanged from its long-run value  $w^*$ , the *efficiency wage*, obtained in (6.8). Thus,

$$w^m = w^*. \quad (6.12)$$

Setting the derivative of the profit function with respect to  $p^m$  equal to zero, given  $w = w^*$ , yields the optimising  $p^m$  as a function of  $\bar{p}$  and  $M$ . Remembering that  $\bar{p}$  is a geometric mean of prices, so that  $\bar{p} = p^{m^{1-\beta}} p^{nm^\beta}$ , and setting  $p^{nm} = p_0$  and

$M = M_0 (1 + \epsilon)$ , one can write<sup>4</sup>

$$p^m = p_0(1 + \epsilon)^\theta, \quad (6.13)$$

where

$$\theta = \frac{(1 - \alpha)/\alpha}{\beta(\eta/\alpha - \eta + 1) + (1 - \beta)(1 - \alpha)/\alpha} \leq 1. \quad (6.14)$$

In this scenario, an increase in money supply shifts upwards the demand curve faced by the firm. As the firm operates under decreasing returns of scale, the marginal cost is upward sloping and profit maximisation leads to an increase in the relative price.

Given the definition of the general level of prices as a geometric mean,  $\bar{p} = p^{m^{1-\beta}} p^{nm^\beta}$ , using (6.11) and (6.13), it follows that

$$\bar{p} = p_0(1 + \epsilon)^{(1-\beta)\theta}. \quad (6.15)$$

Finally, as the nominal wage paid by the non-maximising firms remains at its initial value, one can write

$$w^{nm} = \frac{w^* p_0}{p_0(1 + \epsilon)^{(1-\beta)\theta}} = w^*(1 + \epsilon)^{-(1-\beta)\theta}, \quad (6.16)$$

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<sup>4</sup>See Appendix C.1 for further details.



where  $w^*$  is the *efficiency wage* and  $(1 + \epsilon)^{-(1-\beta)\theta}$  captures the departure of the real wage paid by the non-maximising firms from its long-run equilibrium.

It should be noticed that an increase in the money supply induces the non-maximising firms to hire more labour, to an extent which depends upon the reduction in the relative price of output, the increase in aggregate real balances, and the number of labourers needed to produce output according to the production function. Hence, the average level of employment will be equal to

$$\bar{N} = \frac{1}{[e(w^*)]^{1-\beta} [e(w^*(1 + \epsilon)^{-(1-\beta)\theta})]^\beta} \left[ \frac{M_0(1 + \epsilon)}{p_0(1 + \epsilon)^{(1-\beta)\theta}} \right]^{1/\alpha}. \quad (6.17)$$

The non-neutrality of monetary policy can be easily illustrated since <sup>5</sup>

$$\left. \frac{\partial(\bar{N}/N_0)}{\partial \epsilon} \right|_{\epsilon=0} = \frac{1 + \beta\theta - \theta}{\alpha} + \beta(1 - \beta)\theta \geq 0. \quad (6.18)$$

Given that  $\theta$  is a positive number not higher than one, an increase in the money supply causes an increase in employment. Also, as the fraction of non-maximising firms tends to zero and, thus,  $\beta \rightarrow 0$  and  $\theta \rightarrow 1$ , the model turns into one of monetary neutrality.

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<sup>5</sup>See Appendix C.2 for further details on the algebra of Equation 6.18.

In order to explain whether or not it is reasonable for the firm not to revise prices and nominal wages, Akerlof and Yellen first write the firms' profits, given by Equation (6.3), as functions of  $\epsilon$ , i.e.,:

$$\begin{aligned}\Pi^{nm} &= p_0^{1-\eta} f(\epsilon) - p_0^{-\frac{\eta}{\alpha}} g(\epsilon) h(\epsilon) w^* [e(w^* h(\epsilon))]^{-1}, \\ \Pi^m &= [p_0(1+\epsilon)^\theta]^{1-\eta} f(\epsilon) - [p_0(1+\epsilon)^\theta]^{-\frac{\eta}{\alpha}} g(\epsilon) w^* [e(w^*)]^{-1}.\end{aligned}\tag{6.19}$$

where  $\Pi^m$  denotes the profits of a typical maximising firm and  $\Pi^{nm}$  the profits of a near-rational firm. Furthermore,  $f(\epsilon)$ ,  $g(\epsilon)$  and  $h(\epsilon)$  can be found after substituting  $p_0(1+\epsilon)^{(1-\beta)\theta}$  and  $M_0(1+\epsilon)$  for  $\bar{p}$  and  $M$ , respectively, into the profit function given by Equation (6.3).

The near-rationality of the firm is justified as the losses to the non-maximising firms, over their maximum possible profits, can be shown to be second order with respect to  $\epsilon$ . After calculating the following derivative,

$$\begin{aligned}\frac{\partial(\Pi^m - \Pi^{nm})}{\partial\epsilon} &= \left\{ (1-\eta)(p^m(\epsilon))^{-\eta} f(\epsilon) \right\} \cdot \frac{\partial p^m}{\partial\epsilon} \\ &+ \left\{ \left(\frac{\eta}{\alpha}\right)(p^m(\epsilon))^{-1-\eta/\alpha} g(\epsilon) w^* (e(w^*))^{-1} \right\} \frac{\partial p^m}{\partial\epsilon} \\ &+ \left\{ w^* [e(h(\epsilon)w^*)]^{-1} - h(\epsilon)w^{*2} \frac{\partial e(h(\epsilon)w^*)}{\partial\epsilon} \cdot [e(h(\epsilon)w^*)]^{-2} \right\} \cdot \frac{\partial h(\epsilon)}{\partial\epsilon} (p_0)^{-\eta/\alpha} g(\epsilon) \\ &+ \left\{ (p^m(\epsilon))^{1-\eta} \frac{\partial f(\epsilon)}{\partial\epsilon} - (p^m(\epsilon))^{-\eta/\alpha} w^* [e(w^*)]^{-1} \frac{\partial g(\epsilon)}{\partial\epsilon} \right\} \\ &- \left\{ (p_0)^{1-\eta} \frac{\partial f(\epsilon)}{\partial\epsilon} - (p_0)^{-\eta/\alpha} h(\epsilon) w^* [e(h(\epsilon)w^*)]^{-1} \frac{\partial g(\epsilon)}{\partial\epsilon} \right\},\end{aligned}\tag{6.20}$$



where  $p_0(1 + \epsilon)^{(1-\beta)\theta}$  has been simplified to  $p^m$ , it can be shown that

$$\left. \frac{\partial(\Pi^m - \Pi^{nm})}{\partial \epsilon} \right|_{\epsilon=0} = 0. \quad (6.21)$$

Indeed, the first three terms in Equation (6.20) are zero for  $\epsilon$  equal to zero because of the first-order condition for  $p^m$  and  $w^*$ , maximands of the profit function  $\Pi^m$ .<sup>6</sup> Furthermore, the fourth and the fifth term in curly brackets also cancel for  $\epsilon$  equal to zero, because  $p^m(0) = p_0$  and  $h(0) = 1$ . This is a key result of Akerlof and Yellen's paper, as it shows that the losses to the non-maximising firms over their maximum possible profits will be only second order with respect to  $\epsilon$ .

Intuitively, the non-maximising firms may be thought of as facing a cost of changing prices and money wages, which is assumed to be constant, independent of the magnitude of the change, and equal to  $\gamma$  in real terms.<sup>7</sup> Therefore, in choosing the optimal level of prices and money wages, the non-maximising firms must balance the opportunity cost of having the *wrong* price and money wage and the cost of changing them. Suppose now that both price and money wage are set so as to be optimal for the value of  $\epsilon = 0$ , and suppose that  $\epsilon$  varies. The non-maximising firms decide not

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<sup>6</sup>Note that  $h(\epsilon) = (1 + \epsilon)^{-(1-\beta)\theta}$  has the property that  $h(0) = 1$ .

<sup>7</sup>Ball and Romer (1990) have argued that the Akerlof and Yellen's model, by itself, is not successful in providing foundations for the Keynesian assumption of nominal rigidity. A combination of a departure from full rationality and small nominal frictions is necessary for substantial nominal rigidities to arise.



to revise nominal variables if and only if:

$$\Pi(p_0(1+\epsilon)^\theta, w^*) - \Pi(p_0, w^*(1+\epsilon)^{-(1-\beta)\theta}) \leq \gamma\bar{p}. \quad (6.22)$$

But, given that

$$\Pi(p_0(1+\epsilon)^\theta, w^*) - \Pi(p_0, w^*(1+\epsilon)^{-(1-\beta)\theta}) \big|_{\epsilon=0} = 0, \quad (6.23)$$

for any fixed cost of changing prices and money wages,  $(\gamma)$ , the monetary authority can always find a small enough monetary surprise  $(\epsilon)$  such that the firm decides not to adjust.<sup>8</sup>

In summary, the model presented shows how changes in aggregate demand can cause significant changes in the level of employment. The model is characterised by two types of monopolistic firms: those who are fully maximisers, ready to take advantage of any single piece of information or profitable opportunity available to them, and those who choose to be maximisers exclusively in the long-run, given that they can only make small gains from altering their behaviour in the short-run. Intuitively, prices might not change in response to modest shifts in costs because of the gap between price and marginal cost in a monopolistic industry. Furthermore, one could think of the non-maximising firms as agents who face small costs of changing

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<sup>8</sup>Here we should note that the money supply *per* firm, a variable entering the firm's profit function, has been excluded to simplify the notation, because it is not a choice variable for the firm.

nominal wages and prices. If, in response to a change in money supply, they find it almost costless not to adjust prices and money wages, these small costs will lead to real effects of nominal money. The firms' behaviour can be labelled as near-rational because, even if they behave suboptimally and suffer from losses from not adjusting, those losses are very small. Properly speaking, the losses derived from the monetary policy shock are second order losses.

There are many explanations of the sources of these fixed costs incurred when prices are changing.<sup>9</sup> Carlton (1989) has recognised that the monopolistic discipline includes a certain degree of price rigidity: firms are reluctant to change prices because there is a risk that a price war could break out, any time a price change occurs. He also suggests that, because the customer might interpret price changes as a signal that market conditions are varying, monopolistic firms are willing to not accommodate temporary or small shocks. Menu costs of relabelling prices on items have been also accepted as an interpretation for price rigidity.

The Akerlof and Yellen model is, no doubt, one of the most salient expositions of the New Keynesian tradition. As a framework in which agents do not have much of a local incentive to revise nominal variables, it is an excellent microfoundation for a world with nominal rigidities. In this paper, however, the credibility problem of monetary policy is not considered. Obviously, what the authors want to show is that,

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<sup>9</sup>See, for example, Blinder (1991).



even if anticipated, monetary policy might have real effects.

In the *standard* time consistency model, it is assumed that some agents are pre-committed to nominal variables (usually, the nominal wage). Indeed, the assumption of some kind of nominal rigidity is central to the model: without nominal rigidities, the time consistency problem of the optimal monetary policy would not exist.<sup>10</sup> In some way, infinite menu costs or less than near-rational behaviour have been assumed to explain the nominal rigidities presented in all the papers about the time consistency problem of the optimal monetary policy. This is a very strong assumption since renegotiation is presumably possible, when these agents obtain large gains from changing their nominal variables.

As we show in the next section, the importance of studying a monetary game that includes a microfoundation to explain the existence of nominal rigidities is not purely aesthetic. Indeed, the incorporation of microfoundations, such as near-rational behaviour and fixed costs of changing prices, may well lead to the non-existence of an equilibrium in pure strategies.

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<sup>10</sup>We have already emphasised that the Akerlof and Yellen (1985) model turns into one of monetary neutrality when the fraction of non-maximising firms tends to zero, i.e., when nominal rigidities are removed.



## 6.3 Credibility problems

It is generally accepted that monetary policy is normally set so as to reconcile a low level of inflation with the need for output or, equivalently, employment stabilisation around certain socially desired levels. According to these models the government chooses the money supply,  $M_t$ , that minimises the following *ad hoc* social loss function

$$\Omega_t = (1 - \lambda) \left( \frac{\bar{N}_t - \tilde{N}}{N_0} \right)^2 + \lambda \left( \frac{\bar{p}_t - \bar{p}_{t-1}}{\bar{p}_{t-1}} \right)^2, \quad (6.24)$$

where  $\bar{p}$  denotes the average price level at time  $t$  and  $\bar{N}_t$  is the average number of workers at period  $t$ .  $\tilde{N}$  denotes the socially desired level of employment,  $N_0$  represents the long-run equilibrium labour demand of the firm, and  $0 \leq \lambda \leq 1$  captures the relative weight that the monetary authority puts on inflation *versus* employment stabilisation.

In a model that embodies monopolistic competition, one could consider the inefficiency associated with monopolistic competition, with output of monopolistically produced goods being too low, as a distortion tempting the monetary institution to inflate. If such a model displays also non-neutrality of money – like the one presented above – this could lead us to conclude that it is possible and desirable for the monetary institution to affect the real economic activity. But, in order to consider this possibility, one needs to take into account the role that expectations about the

future path of money supply play in price and wage determination. Once the government's incentives to affect the real economic activity have been recognised, firms' decisions will be determined by their expectations about the central bank's future behaviour and they will not believe announcements of monetary policy that are time inconsistent.

The discretionary or time consistent equilibrium is the equilibrium where, within the period, the monetary authority cannot precommit to the rate of inflation before the non-maximising firms set their nominal wages and prices. It consists of the following three stages:

**stage 1** At the beginning of each period  $t$ , lagged prices,  $\bar{p}_{t-1}$ , are given. The non-maximising firms, those who face some costs of changing prices and behave in a near-rational way, form their expectations about the money supply,  $M_t$ , and choose their nominal wages and prices,  $p_t^{nm}$  (let us say, in order to print a new catalogue), in advance of the determination of  $M_t$ .

**stage 2** Subsequently,  $M_t$  is chosen. In other words, the deviation away from the rate of money growth anticipated by the non-maximising firms,  $\epsilon$ , is determined.

**stage 3** Finally, the maximising firms choose  $p_t^m$  and the non-maximising firms decide whether to revise or not their prices. Thus,  $\bar{p}_t$  and  $\bar{N}_t$  are determined.

The non-maximising firms and the policy-maker play a non-cooperative game. The



model is solved by *backwards induction*. First, we show that a non-inflationary policy cannot be sustained as an equilibrium. Second, we explain why an equilibrium in pure strategies does not exist, for sufficiently small costs of changing prices.

### 6.3.1 The zero inflation policy is not an equilibrium

In this section we show how the traditional time consistency problem of the optimal monetary policy would arise in a model *à la* Akerlof and Yellen, if costs of changing prices were sufficiently large. For very large costs of changing prices, the monetary authority would suffer from a credibility problem, if it tried to precommit to a zero inflation policy rule. Given that the zero inflation policy is not time consistent, it could not be sustained as an equilibrium.

Suppose that the non-rational firms had chosen  $p_t^{nm} = p_{t-1}$ , which would imply an anticipated rate of money growth equal to zero; the government's best response would be given by the solution to the following minimisation problem:

$$\text{Min } \Omega_t = (1 - \lambda) \left( \frac{\bar{N}_t - \tilde{N}}{N_0} \right)^2 + \lambda \left( \frac{\bar{p}_t - \bar{p}_{t-1}}{\bar{p}_{t-1}} \right)^2. \quad (6.25)$$

Given  $p_t^{nm}$ , the first order condition implies that  $\epsilon$ , the proportional deviation



away from the level of money supply anticipated by the non-maximising firms, which is proportional to the price that they set, should be chosen according to<sup>11</sup>

$$\begin{aligned}
 \frac{\partial \Omega_t}{\partial \epsilon} &= \frac{2\lambda [p_t^{nm}(1+\epsilon)^{(1-\beta)\theta} - \bar{p}_{t-1}]}{\bar{p}_{t-1}^2} p_t^{nm}(1+\epsilon)^{(1-\beta)\theta-1}(1-\beta)\theta \\
 &\quad + \frac{2(1-\lambda)}{N_0^2} \left[ \frac{k^{*-1/\alpha}}{e(w^*)^{(1-\beta)} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta} (1+\epsilon)^{(1+\beta\theta-\theta)/\alpha} - \tilde{N} \right] \\
 &\quad \times \left( \frac{k^{*-1/\alpha}}{e(w^*)^{(1-\beta)} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta} (1+\epsilon)^{(1+\beta\theta-\theta)/\alpha} \right) \\
 &\quad \times \left[ \frac{1}{1+\epsilon} \frac{1+\beta\theta-\theta}{\alpha} - \frac{e(w^*)^{1-\beta} \beta e(w^*(1+\epsilon)^{-(1-\beta)\theta})^{\beta-1}}{e(w^*)^{(1-\beta)} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta} \frac{\partial e}{\partial \tilde{w}} \frac{\partial \tilde{w}}{\partial \epsilon} \right] \\
 &= 0
 \end{aligned}$$

The solution  $p_t^{nm} = p_{t-1}$ , which would deliver zero inflation, can be proved not to be an equilibrium because the government can be better-off by choosing a positive monetary surprise,  $\epsilon > 0$ . Analytically,

$$\begin{aligned}
 \left. \frac{\partial \Omega_t}{\partial \epsilon} \right|_{\epsilon=0} &= \frac{2\lambda \bar{p}_t(1-\beta)\theta(\bar{p}_t - \bar{p}_{t-1})}{\bar{p}_{t-1}^2} \\
 &\quad + 2(1-\lambda) \frac{N_0 - \tilde{N}}{N_0} \left[ \frac{1+\beta\theta-\theta}{\alpha} + \beta(1-\beta)\theta \right] < 0,
 \end{aligned} \tag{6.26}$$

when  $p_t^{nm} = \bar{p}_{t-1} = \bar{p}$ , i.e., when the rate of money growth anticipated by the non-

<sup>11</sup>Here, we assume that  $p_t^{nm}$  is fixed. Although this is not true for all values of  $\epsilon$ , it will be true locally, around the value of  $\epsilon$  anticipated by the non-maximising firms.

maximising firms, which equals zero, is fulfilled.

If the social misery index is decreasing locally, around the rate of money growth anticipated by the non-maximising firms, the government can improve social welfare by choosing an  $\epsilon > 0$ . Given that this is the case when the non-maximising firms anticipate a rate of money growth equal to zero, a non-inflationary strategy cannot be sustained in the equilibrium. The traditional time consistency problem would arise as the policy-maker cannot credibly commit to a zero inflation policy rule. Hence, the near-rational firms must assure themselves that the monetary authority will not systematically inflate by choosing a level of prices different to  $\bar{p}_{t-1}$ . In particular, the non-maximising firms would choose  $p_t^{nm} = p_t^D$ , such that the government had no incentives not to fulfill their expectations, i.e., such that the government had no incentives not to choose an  $\epsilon$  equal to zero. The monetary authority should choose the rate of money growth anticipated by the non-maximising firms, i.e., the following condition should be satisfied:

$$\begin{aligned} \left. \frac{\partial \Omega_t}{\partial \epsilon} \right|_{\epsilon=0} &= \frac{2\lambda \bar{p}_t (1 - \beta) \theta (\bar{p}_t - \bar{p}_{t-1})}{\bar{p}_{t-1}^2} \\ &+ 2(1 - \lambda) \frac{N_0 - \tilde{N}}{N_0} \left[ \frac{1 + \beta\theta - \theta}{\alpha} + \beta(1 - \beta)\theta \right] = 0. \end{aligned} \quad (6.27)$$

Taking the positive root for this expression, one can write

$$\bar{p}_t^D = \frac{\bar{p}_{t-1} + \sqrt{\bar{p}_{t-1}^2 - 4\bar{p}_{t-1}A}}{2}, \quad (6.28)$$

where

$$A = \frac{(1 - \lambda) \left[ \frac{1 + \beta\theta - \theta}{\alpha} + \beta(1 - \beta)\theta \right] (N_0 - \tilde{N})}{N_0 \lambda(1 - \beta)\theta}. \quad (6.29)$$

Given that

$$\frac{1 + \beta\theta - \theta}{\alpha} + \beta(1 - \beta)\theta \geq 0, \quad (6.30)$$

and also that, by assumption from monopolistically produced output,

$$N_0 - \tilde{N} < 0, \quad (6.31)$$

$A$  can be proved to be smaller than zero,  $A < 0$ , so that  $\bar{p}_t^D$  is higher than  $\bar{p}_{t-1}$ . In the presence of near-rational behaviour, a zero inflation policy could not be sustained as an equilibrium. By choosing  $p_t^{nm} = \bar{p}_t^D$ , the near-rational firms would be trying to assure that the monetary authority did not systematically inflate.<sup>12</sup> If the policy-

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<sup>12</sup>Note that, from Equation (6.28) above, if  $p_t^{nm} = \bar{p}_t^D$  was an equilibrium, it would imply that the non-maximising firms' anticipated rate of money growth equalled:

$$M_t = M_{t-1} \left[ 1 + \left( \frac{\sqrt{1 - 4A}}{2} - \frac{1}{2} \right) \right],$$



maker were to choose a level of prices above  $\bar{p}_t^D$ , i.e., an  $\epsilon > 0$ , he would achieve a positive output stimulation equivalent, in terms of welfare, to the cost of bearing higher inflation. Thus, although the model retains the properties for non-neutrality of money, the monetary authority would always prefer not to generate any inflationary surprise.

Before explaining why also  $\bar{p}_t^D$  cannot be sustained as an equilibrium, for small values of  $\gamma$ , let us read in more detail Equations (6.28) and (6.29) above. Equation (6.29) suggests that, if menu costs were extremely large, the size of the inflationary bias would decrease with  $\lambda$ , the monetary authority's concern about inflation, and would increase with  $\frac{N_0 - \tilde{N}}{N_0}$ , the employment loss due to the labour market distortion (in our case, monopolistic competition). The size of the *inflation bias* would also increase with the value of  $\beta$ , the fraction of non-maximising firms, since non-maximising firms increase the marginal benefit of a monetary surprise. Indeed, if  $\beta$  equalled 1 and all firms were non-maximisers, the short-run aggregate supply curve would be horizontal and the inflationary bias would tend to infinity. If the short-run aggregate supply curve was horizontal, i.e.,  $\beta = 1$ , the marginal cost of a monetary expansion would be always zero and there would be no finite value for  $\bar{p}_t^D$  in the absence of precommitment. This is, of course, the justification for having maximising firms in addition to non-maximising firms.

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and that the non-maximising firms' expectations were realised,  $\epsilon = 0$ .

It is important to note that, as  $\gamma$  does not appear in Equation (6.28),  $\bar{p}_t^D$  would not depend upon the size of the cost of changing nominal variables. The intuition for this is clear: if costs of changing nominal wages and prices were taken into account, nominal rigidities could be explained. Given the nominal rigidity, the monetary authority would be *ex-post* tempted to inflate. A positive  $\gamma$ , therefore, would only explain *why* a positive monetary surprise,  $\epsilon > 0$ , as long as sufficiently small not to violate Equation (6.22) above, might lead to a positive marginal benefit.

The real menu cost  $\gamma$  – alternatively, the degree of *irrationality* of the firm – would measure by how much the monetary authority *can* surprise the non-rational firms. But the monetary authority's decision on how much to inflate would not depend upon the size of  $\gamma$ , but upon the marginal costs and marginal benefits derived from such an inflation. At  $\bar{p}^D$ , the marginal cost from further inflation equals its marginal benefit, in terms of output expansion. These variables, however, depend upon the parameters in the social loss function and upon the factors affecting the elasticity of output with respect to inflation – e.g., the fraction of non-maximising firms – not upon the costs of changing prices.

### 6.3.2 The non-existence of an equilibrium in pure strategies

As mentioned before, the strategy  $\bar{p}^D$  does not constitute an equilibrium for small values of  $\gamma$ . In contrast with other examples of monetary policy games, in our frame-



work the real costs of changing nominal variables have been accounted for. By doing so, our model differs from others in that the government can *force* the non-maximising firms to revise prices. If  $\gamma$  is a finite value, the government could always choose an appropriate rate of money growth, which not only did not fulfill the non-maximising firms' expectations, but which also forced them to revise their prices. The latter possibility has been, to our knowledge, always ruled out in monetary policy games. Assuming infinite costs of revising prices, the government is left only with the option of *to fulfill or not to fulfill* the non-maximising firms expectations. Given that a surprise is normally too costly for the government, the policy-maker always ends up fulfilling the firms' expectations. Clearly, for very large values of  $\gamma$ ,  $\bar{p}^D$  could be sustained as an equilibrium. However, this will not be the case when the costs of changing prices and money wages are sufficiently small.

For small values of  $\gamma$ , the government would like to deviate from  $\bar{p}^D$ , had the non-rational firms decided such a price. In particular, if  $p_t^{nm} = \bar{p}_t^D$ , a deviation away from the rate of money growth anticipated by the non-maximising firms equal to:

$$\epsilon = - \left[ \frac{\sqrt{1 - 4A}}{2} - \frac{1}{2} \right].$$

would be equivalent to  $M_t = M_{t-1}$  – see footnote 10 – and would force the firms to revise if, at that point, the condition (6.22) above was violated.



For small values of  $\gamma$ , the government will always prefer to choose:

$$\epsilon = - \left[ \frac{\sqrt{1 - 4A}}{2} - \frac{1}{2} \right].$$

By choosing  $M_t = M_{t-1}$ , the government could keep prices constant at  $\bar{p}_{t-1}$ , so as to avoid the losses of the inflation bias, while, in either case, output would be at the natural rate.<sup>13</sup> This solution is not, thus, an equilibrium, since the non-maximising firms do not have their expectations fulfilled.

Similarly, any level of prices different to  $\bar{p}_t^D$  cannot be sustained as an equilibrium in pure strategies, since for any  $p_t^{nm} \neq \bar{p}_t^D$  the government would find it optimal to choose a positive deviation away from the rate of money growth anticipated by the non-maximising firms, i.e., a positive monetary surprise,  $\epsilon > 0$ , as stated in Equation (6.27); the government will find it optimal to deviate locally (without triggering the menu cost) from the level of prices anticipated by the non-maximising firms. Hence, the rational expectations condition would be violated, as the non-maximising firms get their expectations wrong. In summary, an equilibrium in pure strategies might not exist, when real costs of changing nominal variables are incorporated into monetary policy games.

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<sup>13</sup>It should be pointed out that the government does not take into account the cost of changing nominal variables in its social loss function.

## 6.4 Conclusions

In recent years, new Keynesian economists have made much progress on explaining the rationality of less than fully rational behaviour. It has been demonstrated that near-rational economic agents might choose to create nominal rigidities. Anticipated money supply changes may cause fluctuations in business activity provided that agents are willing to incur very small losses. Furthermore, if monopolistic firms face some cost of changing prices, they may decide to revise prices only when the opportunity costs of not doing so are sufficiently large.

The literature, however, has not paid enough attention to the problems that both near-rationality and fixed costs of changing prices present for the credibility problem of monetary policy. Somehow, costs of changing prices or near-rational behaviour have been assumed to explain the nominal rigidities presented in all the papers about the time consistency problem of monetary policy. But, to our knowledge, they have never been incorporated into the analysis. This chapter attempts to do so.

Rather than assuming nominal rigidities, we have borrowed one of the best-known frameworks for the explanation of the rigidity of prices. Then, we have incorporated the credibility problem of monetary policy to the analysis. From a theoretical point of view, near-rational behaviour seems to open a new spectrum of problems in monetary policy games. What we have shown is that combining microfoundations for nominal

rigidities and credibility problems may lead to the non-existence of an equilibrium in pure strategies. It would be very interesting to find out whether an equilibrium in mixed strategies can be found. But this is a question that we shall leave for further research.



## Chapter 7

# Conclusions

Keynesian economics have been characterised as the economics of nominal (and real) rigidities, where the role for monetary policy stabilisation can be justified and monetary policy intervention called for.

On the other hand, New classical economists typically insist on the need to reduce monetary stabilisation to its minimum. This is because, in the presence of nominal rigidities, a monetary authority that is concerned over, let us say, employment has incentives to create monetary surprises. As a result, in order to control this credibility problem, the monetary authority should focus on the control of inflation, without further considerations.

But when supply-side shocks are considered, the policy-maker would like to retain

some flexibility to stabilise output. In recent years an important amount of research has been undertaken in order to design central bank constitutions that may solve these incentive problems but that, at the same time, allow the central banker to stabilise output optimally.

What we have shown in this thesis is that the microeconomic details of wage – and price – setting not only affect the costs (benefits) of credible disinflationary (inflationary) policy, but that they need to be considered to determine whether those disinflationary (inflationary) policies can be perceived as credible or not.

This idea has been illustrated with two main examples:

First, we have presented an economy where unemployment persistence could be generated if only employed *insiders* mattered for wage setting. In Chapter 3 it has been shown how the benefits of output stabilisation seriously increase when there is serial correlation in output. With output persistence, however, a small increase in current inflation not only increases today's output but also future levels since output benefits persist. The credibility problem of monetary policy is, therefore, enhanced in the presence of output persistence. Moreover, unemployment persistence appears to add significantly to the already difficult implementation of some monetary constitutions. The suitability of different central bank constitutions has been analysed in Chapter 4. We have emphasised the difficulties that a country like Spain, with a



highly distorted labour market, may face in fighting inflation.

A second mechanism of introducing wage setting dynamics has been presented in Chapter 5, where long-term staggered wage setting is taken into account. Once again, the microeconomic details of wage setting add significance to the time consistency problem of the optimal monetary policy. Period by period precommitment to zero inflation is not sufficient to eliminate the inflationary bias of the economy, if workers are setting wage contracts that last for more than a period. Allowing for long-term precommitment leads us to the result that, even in a deterministic framework, commitment to zero inflation policies may not be credible. Furthermore, as suggested by Drazen and Masson (1994), following a tough monetary policy in the presence of unemployment persistence may actually harm rather than enhance credibility, if the public perceives that the government will not be able to ignore pressures to restore high employment in the future.

A different but still related result has been shown in Chapter 6. We have investigated how the introduction of microfoundations that allow us to explain nominal rigidities affect the credibility problem of monetary policy. We have shown that there is no equilibrium in pure strategies when near-rationality or, alternatively, costs of changing prices are incorporated into monetary policy games.

There are various lessons to be learnt. First, the microfoundations of wage – and



price – setting are too important to be ignored at the time of designing efficient resolutions to the credibility problem of monetary policy. Not only are the costs and the benefits of anti-inflationary policy strictly related to the market structure of the economy, but so also are the incentives tempting the monetary authority to inflate. It is, therefore, dangerous to disregard the market structure of the economy when recommendations for central bank institutional design are being given.

Second, the empirical literature on central bank independence should be carefully revised. To our knowledge, no empirical work takes into account the peculiarities of the market structure of the economy, when measuring the institutional success in controlling inflation across countries. For example, a central banker with a certain degree of *conservativeness* would perform very differently in two different countries, if those countries happened to have very different labour markets. Third, the introduction of special characteristics of market structure raises general doubts about the inconsistency model, as a positive theory of macroeconomic policy. The literature on the time consistency problem of the optimal monetary policy focuses on normative economics about what central banks *should do*, based upon behavioural assumptions, that may or may not capture what is happening in the real world. What appears to be missed in this literature is a more positive analysis of what central banks actually *do*.

Finally, countries like Spain seem to have found ways to institute a reputation for

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fighting inflation: the level of Spanish inflation does not correspond to that predicted in the literature for a country with such a highly distorted labour market. *Reputational* effects may be significantly large, so that the optimal feedback policy could be implemented without too many difficulties.

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# Appendix A

## Appendix to Chapter 3

### A.1 The Demand Effects in the Periphery of an Idiosyncratic Supply Shock to the Core Country

The results shown in Figure 3.1 can be derived formally from the following two country model (This is essentially a simplified version of Canzoneri and Henderson's analysis, to which the reader is referred for a more comprehensive treatment).

Let the total money demand in the two countries, core and periphery, be denoted

$$M = py + p^*y^*, \tag{A.1}$$

where variables in the core country are labelled with an asterisk. Assuming both are

the same size, we can write this in terms of growth rates as follows

$$g_M = \frac{1}{2}(\pi + g_y) + \frac{1}{2}(\pi^* + g_{y^*}), \quad (\text{A.2})$$

or

$$g_M = \frac{1}{2}(\pi + x) + \frac{1}{2}(\pi^* + x^*), \quad (\text{A.3})$$

where  $x$  denotes the percentage shift in output.

Assuming both countries start in equilibrium, where  $y = \bar{y}$ , and assuming also that  $\pi^e = \pi^{*e} = 0$  we may write the short run supply curves as

$$x = \beta(\pi - \pi^e) = \beta\pi, \quad (\text{A.4})$$

$$x^* = \beta(\pi^* - \pi^{*e} + u^*) = \beta(\pi^* + u^*), \quad (\text{A.5})$$

where  $u^*$  is the idiosyncratic supply shock in the core, measured as a percentage of output in the core country.

Let us assume that differential inflation shifts demand between the two areas, so

$$g_y - g_{y^*} = \alpha(\pi^* - \pi) \quad (\text{A.6})$$

and so in the short run

$$x - x^* = \alpha(\pi^* - \pi). \quad (\text{A.7})$$

Assume now that monetary policy is set so as to check inflation in the core country, i.e., it is as if policy has been delegated to a conservative central bank in the core country. For simplicity, assume  $\pi^* = 0$ , so there is no inflation in the core country. Then, given from (A.5) that  $x^* = \beta u^*$ , from (A.4) and (A.7) we find

$$\pi = \frac{\beta}{\alpha + \beta} u^*, \quad (\text{A.8})$$

and

$$x = \frac{\beta^2}{\alpha + \beta} u^*. \quad (\text{A.9})$$

The growth of money demand in the two countries together can be obtained by substitution into (A.3) to give

$$g_M = \frac{1}{2} \left[ \frac{\beta}{\alpha + \beta} u^* + \frac{\beta^2}{\alpha + \beta} u^* + \beta u^* \right] = \left[ \frac{2\beta^2 + \beta(1 + \alpha)}{2(\alpha + \beta)} \right] u^*. \quad (\text{A.10})$$

As an example, take the case where the supply curves have unit elasticity,  $\beta = 1$ ,



so

$$g_M = \frac{3 + \alpha}{2(1 + \alpha)} u^* \begin{cases} > \\ = \\ < \end{cases} u^* \text{ as } \alpha \begin{cases} < \\ = \\ > \end{cases} 1. \quad (\text{A.11})$$

If, further,  $\alpha = 1$  then  $g_M = u^* = x^* = 2x$ , equalities used in Figure 3.1 to illustrate the consequences of an asymmetric adverse productivity shock ( $u^* > 0$ ).

## A.2 Optimal Delegation with Autoregressive Output

In the absence of precommitment, with autoregressive output, the government delegates monetary policy to a weight-conservative, myopic central banker. Such a policy-maker will set monetary policy so as to minimise:

$$M_t = \lambda_b \pi_t^2 + (1 - \lambda_b) [k\bar{y} - y_t]^2, \quad (\text{A.12})$$

subject to

$$y_t - \bar{y} = \rho(y_{t-1} - \bar{y}) + \alpha(\pi_t - \pi_t^e) + u_t, \quad (\text{A.13})$$

taking expected inflation,  $\pi_t^e$ , as given. Furthermore,  $u_t$  is i.i.d. normal, with variance  $\sigma_u^2$ , and  $1 \geq \lambda_b \geq 0$  measures the weight preferences of the central banker.

The central banker's reaction function is obtained as the first order condition to the problem above, which, after substituting  $\frac{1-\lambda_b}{\lambda_b} = \gamma$ , gives us:

$$\pi_t = \gamma\alpha [k\bar{y} - y_t]. \quad (\text{A.14})$$

Substituting out Equation (A.14) into (A.12), the misery index at time  $t$  can be rewritten to read:

$$M_t = (1 + \alpha^2\gamma^2) [k\bar{y} - y_t]^2. \quad (\text{A.15})$$

Yet, substituting out Equation (A.14) and  $\pi_t^e = \gamma\alpha [(k-1)\bar{y}]$  into (A.13), one can write

$$y_t - \bar{y} = \rho(y_{t-1} - \bar{y}) + \frac{1}{1 + \gamma\alpha^2} u_t. \quad (\text{A.16})$$

Now, if we define:

$$(1 + \alpha^2\gamma) \cdot (y_{t-1} - \bar{y}) = \epsilon_{t-1}, \quad (\text{A.17})$$

the misery index can be written as:

$$M_t = (1 + \alpha^2 \gamma^2) \left[ (k-1)\bar{y} - \frac{\epsilon_t}{1 + \alpha^2 \gamma} \right]^2, \quad (\text{A.18})$$

where  $y_t - \bar{y}$  follows an autoregressive process

$$(1 + \alpha^2 \gamma) \cdot (y_t - \bar{y}) = \epsilon_t = \rho \epsilon_{t-1} + u_t. \quad (\text{A.19})$$

$u_t$  is i.i.d. normal with variance  $\sigma_u^2$ , namely,

$$E(u_s | \mathcal{F}_t) = \begin{cases} 0, & \text{if } s \geq t, \\ u_s, & \text{if } s < t; \end{cases} \quad (\text{A.20})$$

$$E(u_s u_{s'} | \mathcal{F}_t) = \begin{cases} 0, & \text{if } s \neq s' \text{ and } s, s' \geq t, \\ \sigma_u^2, & \text{if } s = s' \text{ and } s, s' \geq t, \end{cases} \quad (\text{A.21})$$

where  $\mathcal{F}_t$  contains all the information available at the beginning of period  $t$ .

The expected misery index in infinite time horizon is defined as

$$z = \sum_{j=0}^{\infty} E\left(\frac{M_j}{(1 + \theta)^j} | \mathcal{F}_0\right), \quad (\text{A.22})$$

where  $\theta$  is a discount rate.



From (A.19), one finds

$$\epsilon_j = \rho^{j+1}\epsilon_{t-1} + \sum_{i=0}^j \rho^i u_{j-i}. \quad (\text{A.23})$$

Taking expectation conditional on the information at  $t = 0$ , using (A.20), one derives

$$E(\epsilon_j|\mathcal{F}_0) = \rho^{j+1}\epsilon_{t-1}. \quad (\text{A.24})$$

Using (A.20), (A.21) and (A.23), the expectation of  $\epsilon_j^2$  becomes

$$E(\epsilon_j^2|\mathcal{F}_0) = \rho^{2(j+1)}\epsilon_{t-1}^2 + \frac{\rho^{2(j+1)} - 1}{\rho^2 - 1} \cdot \sigma_u^2. \quad (\text{A.25})$$

Using (A.24) and (A.25), the expectation of  $M_j$  becomes

$$\begin{aligned} E(M_j|\mathcal{F}_0) &= (1 + \alpha^2\gamma^2)[(k-1)^2\bar{y}^2 - \frac{2(k-1)\bar{y}}{1 + \alpha^2\gamma} \cdot \rho^{j+1}\epsilon_{t-1} \\ &\quad + \frac{\rho^{2(j+1)}\epsilon_{t-1}^2}{(1 + \alpha^2\gamma)^2} + \frac{\rho^{2(j+1)} - 1}{(1 + \alpha^2\gamma)^2(\rho^2 - 1)} \cdot \sigma_u^2]. \end{aligned} \quad (\text{A.26})$$

So

$$\begin{aligned} z &= (1 + \alpha^2\gamma^2)\left\{(k-1)^2\bar{y}^2\frac{1+\theta}{\theta} - \frac{2(k-1)}{(1 + \alpha^2\gamma)}\frac{\rho(1+\theta)}{(1+\theta-\rho)}\bar{y}\epsilon_{t-1}\right. \\ &\quad \left.+ \frac{\rho^2(1+\theta)\epsilon_{t-1}^2}{(1 + \alpha^2\gamma)^2(1+\theta-\rho^2)} + \frac{(1+\theta)^2\sigma_u^2}{(1 + \alpha^2\gamma)^2\theta(1+\theta-\rho^2)}\right\}. \end{aligned} \quad (\text{A.27})$$

When  $\epsilon_{t-1} = 0$ , the above equation is simplified as

$$z = \frac{1+\theta}{\theta} \left\{ (k-1)^2 \bar{y}^2 + \frac{(1+\theta)\sigma_u^2}{(1+\alpha^2\gamma)^2(1+\theta-\rho^2)} \right\} \cdot (1+\alpha^2\gamma^2). \quad (\text{A.28})$$

Optimal  $\gamma^{**}$  satisfies:

$$\frac{\partial z}{\partial \gamma} = 0,$$

or

$$(1+\alpha^2\gamma^{**})^3 = \frac{1-\gamma^{**}}{\gamma^{**}} \cdot \frac{(1+\theta)\sigma_u^2}{(1+\theta-\rho^2)(k-1)^2\bar{y}^2}. \quad (\text{A.29})$$

### A.3 The optimal feedback rule with output persistence

With output persistence, the optimal feedback rule for the inflation rate is derived as the solution to the problem

$$V(y_{t-1} - \bar{y}) = \underset{\pi_t}{\text{Min}} E_{t-1} \left\{ \pi_t^2 + (k\bar{y} - y_t)^2 + \delta V(y_t - \bar{y}) \right\}, \quad (\text{A.30})$$

subject to

$$y_t - \bar{y} = \rho(y_{t-1} - \bar{y}) + \alpha(\pi_t - \pi_t^e) + u_t, \quad (\text{A.31})$$

and

$$E_{t-1}\pi_t = \pi_t^e, \quad (\text{A.32})$$

where  $V(y_t - \bar{y})$  is obtained by an identical optimisation procedure at  $t + 1$ .

Moreover, we can denote as  $V(y_t - \bar{y}) = \beta_0 + \beta_1(y_{t-1} - \bar{y}) + 2\beta_2(y_{t-1} - \bar{y})^2$  the present discounted value of the misery index from  $t$  onwards, where the coefficients  $\beta_0$ ,  $\beta_1$  and  $\beta_2$  need to be determined.<sup>1</sup>

The FOC to our problem implies:

$$\begin{aligned} \pi_t = & \alpha(1 - E_{t-1}) [(k-1)\bar{y} - \rho(y_{t-1} - \bar{y}) - \alpha(\pi_t - E_{t-1}\pi_t) - u_t] \\ & - \frac{\delta}{2} \frac{\partial V(y_t - \bar{y})}{\partial(y_t - \bar{y})} \frac{\partial(y_t - \bar{y})}{\partial\pi_t}. \end{aligned} \quad (\text{A.33})$$

Taking expectations at  $t - 1$  on (A.33) implies

$$\pi_t^e = 0, \quad (\text{A.34})$$

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<sup>1</sup>In Chapter 5 we describe this optimisation procedure in more detail.



so that the optimal rule is

$$\pi_t = - \left( \frac{\alpha + 2\delta\alpha\beta_2}{1 + \alpha^2 + 2\alpha^2\delta\beta_2} \right) u_t. \quad (\text{A.35})$$

To solve our problem,  $\beta_2$  needs to be determined. The following condition needs to be satisfied

$$\begin{aligned} V(y_{t-1} - \bar{y}) &= \beta_0 + \beta_1(y_{t-1} - \bar{y}) + 2\beta_2(y_{t-1} - \bar{y})^2 \\ &= E_{t-1} [\pi_t^2 + (k\bar{y} - y_t)^2 + \delta V(y_t - \bar{y})]. \end{aligned} \quad (\text{A.36})$$

This implies,

$$\begin{aligned} \beta_0 + \beta_1(y_{t-1} - \bar{y}) + 2\beta_2(y_{t-1} - \bar{y})^2 &= \frac{\alpha^2}{(1 + \alpha^2 - \delta\rho^2)^2} \sigma_u^2 + (k-1)^2 \bar{y}^2 \\ &\quad + \rho^2(y_{t-1} - \bar{y})^2 + \sigma_u^2 \left( \frac{1 - \delta\rho^2}{1 + \alpha^2 - \delta\rho^2} \right)^2 \\ &\quad - 2(k-1)\bar{y}\rho(y_{t-1} - \bar{y}) + \delta\beta_0 + \delta\beta_1\rho(y_{t-1} - \bar{y}) \\ &\quad + 2\delta\beta_2 \left[ \rho^2(y_{t-1} - \bar{y})^2 + \left( \frac{1 - \delta\rho^2}{1 + \alpha^2 - \delta\rho^2} \right)^2 \sigma_u^2 \right]. \end{aligned} \quad (\text{A.37})$$

Equalising coefficients in both sides of the previous expression, we obtain

$$\beta_2 = \frac{\rho^2}{2(1 - \delta\rho^2)}, \quad (\text{A.38})$$

$$\beta_1 = -\frac{2(k-1)\rho\bar{y}}{1-\delta\rho}, \quad (\text{A.39})$$

and

$$\beta_0 = \frac{1}{1-\delta} \left\{ (k-1)^2 \bar{y}^2 + \sigma_u^2 \left[ \frac{\alpha^2}{(1+\alpha^2-\delta\rho^2)^2} + (1+2\delta\beta_2) \left( \frac{1-\delta\rho^2}{1+\alpha^2-\delta\rho^2} \right)^2 \right] \right\}. \quad (\text{A.40})$$

Therefore, substituting  $\beta_2$  into the expression for inflation leads to

$$\pi_t = -\frac{\alpha}{1-\delta\rho^2+\alpha^2} u_t. \quad (\text{A.41})$$

With output persistence, inflation is allowed to fluctuate more in order to stabilise output in the presence of supply-side shocks.

# Appendix B

## Appendix to Chapter 5

### B.1 Proof

That the state variables  $p_{t-1}$  and  $x_{t-1}$  enter the wage setters' reaction function, and the value function, as the difference

$$p_{t-1} - x_{t-1} = z_{t-1}$$

Let us, first, propose the following value function for the policy-maker:

$$V(p_{t-1}, x_{t-1}) = \psi_0 + \psi_1 p_{t-1} + \psi_2 x_{t-1} + \psi_3 p_{t-1} x_{t-1} + \psi_4 p_{t-1}^2 + \psi_5 x_{t-1}^2, \quad (\text{B.1})$$

where  $p_{t-1}$  and  $x_{t-1}$  enter  $V(p_{t-1}, x_{t-1})$  in a general form.



Let us also apply Bellman's principle of optimality which states, in this case, that

$$V(p_{t-1}, x_{t-1}) = \underset{m_t}{\text{Min}} [(1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2 + \delta V(p_t, x_t)], \quad (\text{B.2})$$

where  $p_t$  and  $x_t$  are the state variables of the system, and  $V(p_{t-1}, x_{t-1})$  is the optimised value function for the policy-maker at time  $t$ , given the lagged value for the state variables.

We will demonstrate that there is a Markov perfect equilibrium (MPE) where the state variables  $p_t$  and  $x_t$  enter into the value function in difference form, i.e.,  $V(p_t - x_t) = V(z_t)$ .

In particular, we will assume that  $V(p_t, x_t) = V(z_t)$  in the right hand side (RHS) of Equation (B.2), so that  $V(z_t) = \beta_0 + \beta_1 z_{t-1} + \beta_2 z_{t-1}^2$ . A second assumption will consist of substituting out  $x_t$  in the RHS of (B.2) by  $x_t = \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 p_{t-1}$ . Finally, it will be shown that, after taking into account rational expectations on the part of the private sector, all this implies that the value function also takes the same form on the left hand side (LHS) of (B.2). This, therefore, establishes that there exists a MPE such that  $V(p_t, x_t) = V(z_t)$ .

Although there may be other solutions to our problem, we only intend to show that there is one that takes the form we propose.

Hence, we write:

$$V(p_{t-1}, x_{t-1}) = \underset{m_t}{\text{Min}} [(1 - \lambda)(y_t - \tilde{y})^2 + \lambda(p_t - p_{t-1})^2 + \delta(\beta_0 + \beta_1 z_t + \beta_2 z_t^2)], \quad (\text{B.3})$$

where

$$p_t = \frac{1}{1+\rho} \left[ \rho m_t + \frac{1}{2} (x_t + x_{t-1}) \right], \quad (\text{B.4})$$

$$y_t = \frac{1}{1+\rho} \left[ m_t - \frac{1}{2} (x_t + x_{t-1}) \right], \quad (\text{B.5})$$

as given in Equations (5.10) and (5.11).

The monetary authority chooses  $m_t$  so as to minimise the expression above, subject to the Equations (B.4) and (B.5), taking  $x_t$  as given. We can, then, show that the first order condition (FOC) to (B.3) implies:

$$\begin{aligned} m_t = & 2A(1+\rho)(1-\lambda)\tilde{y} - A(1+\rho)\delta\rho\beta_1 + 2A\lambda\rho(1+\rho)p_{t-1} \\ & + 2A(1+\rho)\delta\rho\beta_2x_t - A[(\lambda-1) + \lambda\rho + \delta\rho\beta_2](x_t + x_{t-1}), \end{aligned} \quad (\text{B.6})$$

where

$$A = \frac{1}{2(1-\lambda + \lambda\rho^2 + \delta\rho^2\beta_2)}.$$

The monetary authority treats  $x_t$  as given. Yet, if we assume that

$$x_t = \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 p_{t-1}, \quad (\text{B.7})$$

on the RHS of (B.6), we can write:

$$\begin{aligned} m_t = & 2A(1 + \rho)(1 - \lambda)\tilde{y} - A(1 + \rho)\delta\rho\beta_1 \\ & + B\alpha_0 + Cx_{t-1} + Dp_{t-1} + B\alpha_1z_{t-1}, \end{aligned} \quad (\text{B.8})$$

where

$$\begin{aligned} A &= \frac{1}{2(1 - \lambda + \lambda\rho^2 + \delta\rho^2\beta_2)}, \\ B &= A \cdot [\beta_2\delta\rho(1 + 2\rho) + 1 - \lambda - \lambda\rho], \\ C &= A \cdot (1 - \lambda - \lambda\rho - \beta_2\delta\rho), \\ D &= A \cdot [(\beta_2\delta\rho + \rho\lambda)(1 + 2\rho) + 1 - \lambda]. \end{aligned}$$

Rational expectations on the wage setters' side imply, however, that they choose their wage contract according to:

$$x_t = \frac{\hat{p}_t + \hat{p}_{t+1}}{2}. \quad (\text{B.9})$$

We shall, therefore, prove that the wage setters' reaction function given by Equation (B.7) satisfies rationality.

Indeed, it can be shown, after substituting out Equations (B.4), (B.7) and (B.8) into Equation (B.9), that the parameters  $\alpha_0$  and  $\alpha_1$  entering the wage setters' reaction



function satisfy the rational expectations condition if:

$$\begin{aligned} \alpha_0 = & \left[ 2A(1+\rho)(1-\lambda)\rho\tilde{y} - A(1+\rho)\delta\rho^2\beta_1 \right] \cdot \\ & \left[ \frac{1}{1+\rho} + \frac{1}{2(1+\rho)^2} \left( \rho D + \frac{1}{2} + \alpha_1\rho B + \frac{\alpha_1}{2} \right) \right] + \frac{\alpha_0}{2(1+\rho)} \cdot \\ & \left[ \left( 2\rho B + \frac{3}{2} + \rho C - \frac{\alpha_1}{2} - \alpha_1\rho B \right) + \frac{1}{1+\rho} \cdot \left( \rho D + \frac{1}{2} + \alpha_1\rho B + \frac{\alpha_1}{2} \right) \left( \rho B + \frac{1}{2} \right) \right], \end{aligned}$$

and

$$\begin{aligned} \alpha_1 = & \left[ \left( \rho B + 1 + \rho C - \frac{\alpha_1}{2} - \alpha_1\rho B \right) + \frac{1}{(1+\rho)} \left( \rho D + \frac{1}{2} + \alpha_1\rho B + \frac{\alpha_1}{2} \right) \left( \rho B + \frac{1}{2} \right) \right] \cdot \\ & \frac{\alpha_1 z_{t-1}}{2(1+\rho)} + \frac{1}{2(1+\rho)^2} \left( \rho D + \frac{1}{2} + \alpha_1\rho B + \frac{\alpha_1}{2} \right) \left( \rho D - \frac{1}{2} - \rho \right) z_{t-1} + \\ & \frac{1}{2(1+\rho)} \left( \rho D - \frac{1}{2} - \rho \right) z_{t-1}. \end{aligned}$$

Furthermore, for these values,  $\alpha_0$  and  $\alpha_1$ , the coefficient associated to  $p_{t-1}$  will be simplified till it equals one.

Having shown that there is a solution where  $x_t$  may be written as a linear function of  $z_{t-1}$  and  $p_{t-1}$  only, as stated in (B.7), the next step will be to show that  $m_t = \gamma_0 + \gamma_1 z_{t-1} + \gamma_2 p_{t-1}$ . Hence, reorganising terms in (B.6), it can be written:

$$\begin{aligned} m_t = & 2A(1+\rho)(1-\lambda)\tilde{y} - A(1+\rho)\delta\rho\beta_1 + 2A\beta_2\delta\rho(1+\rho)x_t \\ & + A[(\lambda-1) + \lambda\rho + \delta\rho\beta_2](z_{t-1} - x_t) + A[2\lambda\rho(1+\rho) - (\lambda-1) - \lambda\rho - \delta\rho\beta_2]p_{t-1}. \end{aligned} \tag{B.10}$$

Substituting out the expression for  $x_t$ , as given in (B.7), an expression for  $m_t$  will arise such that:

$$m_t = \gamma_0 + \gamma_1 z_{t-1} + p_{t-1}, \quad (\text{B.11})$$

where

$$\begin{aligned} \gamma_0 = & 2A(1 + \rho)(1 - \lambda)\tilde{y} - A(1 + \rho)\delta\rho\beta_1 + \\ & A[2\beta_2\delta\rho(1 + \rho) - (\lambda - 1) - \lambda\rho - \delta\rho\beta_2]\alpha_0, \end{aligned} \quad (\text{B.12})$$

and

$$\gamma_1 = A\{2\beta_2\delta\rho(1 + \rho) + [(\lambda - 1) + \lambda\rho + \delta\rho\beta_2](1 - \alpha_1)\}. \quad (\text{B.13})$$

Before showing that there exists a solution where  $p_{t-1}$  and  $x_{t-1}$  enter the monetary authority's value function in a difference form, let us stress that, now, (B.4) can be read as

$$p_t = \mu_0 + \mu_1 z_{t-1} + p_{t-1}, \quad (\text{B.14})$$

where

$$\mu_0 = \frac{1}{1 + \rho} \left[ \rho\gamma_0 + \frac{\alpha_0}{2} \right], \quad (\text{B.15})$$

and

$$\mu_1 = \frac{1}{1+\rho} \left[ \rho\gamma_1 + \frac{\alpha_1 - 1}{2} \right]. \quad (\text{B.16})$$

Also,  $y_t$  in (B.5) can be expressed as  $y_t = \eta_0 + \eta_1 z_{t-1}$ , where

$$\eta_0 = \frac{1}{1+\rho} \left[ \gamma_0 - \frac{\alpha_0}{2} \right], \quad (\text{B.17})$$

and

$$\eta_1 = \frac{1}{1+\rho} \left[ \gamma_1 - \frac{(\alpha_1 - 1)}{2} \right]. \quad (\text{B.18})$$

Finally,  $z_t = p_t - x_t$  will look like

$$z_t = (\mu_0 - \alpha_0) + (\mu_1 - \alpha_1)z_{t-1}, \quad (\text{B.19})$$

or, alternatively,

$$z_t = \theta_0 + \theta_1 z_{t-1}, \quad (\text{B.20})$$

if  $\theta_0 = \mu_0 - \alpha_0$  and  $\theta_1 = \mu_1 - \alpha_1$ .

Hence, having demonstrated that there is a solution to our problem where the real variables  $y_t$ ,  $z_t$  can be written as a linear function of  $z_{t-1}$  only, and where the nominal variables,  $p_t$  and  $m_t$ , are linear functions of  $z_{t-1}$  and  $p_{t-1}$  only, it will be very simple to show that this all implies that the social value function is a linear quadratic



function on  $z_{t-1}$  only. In fact, after substituting out Equations (B.14), (B.17), (B.20) into the RHS of Equation (B.2), we obtain

$$V(p_{t-1}, x_{t-1}) = \underset{m_t}{Min} (1 - \lambda)(\eta_0 + \eta_1 z_{t-1} - \tilde{y})^2 + \lambda(\mu_0 + \mu_1 z_{t-1})^2 + \delta\beta_0 + \delta\beta_1(\theta_0 + \theta_1 z_{t-1}) + \delta\beta_2(\theta_0 + \theta_1 z_{t-1})^2. \quad (\text{B.21})$$

This, therefore, establishes that there exists a solution to our problem where  $p_{t-1}$  and  $x_{t-1}$  enter the value function in a difference form, and such that:

$$V(z_{t-1}) = \beta_0 + \beta_1 z_{t-1} + \beta_2 z_{t-1}^2, \quad (\text{B.22})$$

where

$$\beta_0 = (1 - \lambda)(\eta_0 - \tilde{y})^2 + \lambda\mu_0^2 + \delta(\beta_0 + \beta_1\theta_0 + \beta_2\theta_0^2), \quad (\text{B.23})$$

$$\beta_1 = (1 - \lambda)(\eta_0 - \tilde{y})\eta_1 + \lambda\mu_0\mu_1 + \delta(\beta_1\theta_1 + \beta_2\theta_0\theta_1), \quad (\text{B.24})$$

and

$$\beta_2 = (1 - \lambda)\eta_1^2 + \lambda\mu_1^2 + \delta\beta_2\theta_1^2. \quad (\text{B.25})$$

## B.2 The time consistent equilibrium

### B.2.1 Solving for $\alpha_1$ , $\beta_2$ , $\beta_1$ and $\alpha_0$

Our consistency conditions lead to the following relationships

For  $\alpha_1$ :

$$\alpha_1 = \frac{(1 + \rho + \rho D + \frac{1}{2} + \alpha_1 \rho B + \frac{\alpha_1}{2}) (\alpha_1 \rho B + \frac{\alpha_1}{2} - \rho C - \frac{1}{2})}{(1 + \rho) [2(1 + \rho) - \rho C - \frac{1}{2} + \alpha_1 \rho B + \frac{\alpha_1}{2}]}$$

Making use of the relationship  $C + D = 1$ , and simplifying, one can write

$$\alpha_1 = - \left( \frac{\frac{1}{2} + \rho C}{\frac{1}{2} + \rho - \rho B} \right) = \frac{\lambda - 1}{1 - \lambda + 2\lambda\rho^2}. \quad (\text{B.26})$$

For  $\beta_2$ :

$$\begin{aligned} \beta_2 = & \frac{1}{(1 + \rho)^2} \lambda \left( \rho D + \alpha_1 \rho B + \frac{\alpha_1}{2} - \frac{1}{2} - \rho \right)^2 \\ & + \frac{1}{(1 + \rho)^2} (1 - \lambda) \left( D - \frac{1}{2} + \alpha_1 B - \frac{\alpha_1}{2} \right)^2 \\ & + \frac{\delta\beta_2}{(1 + \rho)^2} \left[ \rho D + \frac{1}{2} - (\alpha_1 + 1)(1 + \rho) + \alpha_1 \rho B + \frac{\alpha_1}{2} \right]^2. \end{aligned}$$

Using  $C + D = 1$ , substituting  $\alpha_1$  and simplifying, one finds

$$\beta_2 = \frac{(1 - \lambda)\lambda(1 - \lambda + \lambda\rho^2)}{(1 - \lambda + 2\lambda\rho^2)^2}. \quad (\text{B.27})$$

For  $\alpha_0$ :

$$\alpha_0 = \frac{[2(1+\rho) + \rho D + \frac{1}{2} + \alpha_1 \rho B + \frac{\alpha_1}{2}]}{[2(1+\rho) - \frac{1}{2} - \rho C + \alpha_1 \rho B + \frac{\alpha_1}{2}]} \times \left[ 2A\rho(1-\lambda)\tilde{y} - A\delta\rho^2\beta_1 + \alpha_0 \left( \frac{\rho B + \frac{1}{2}}{1+\rho} \right) \right],$$

that, after simplifying, becomes

$$\alpha_0 = \frac{2A(1-\lambda+3\lambda\rho^2)}{1-\lambda+4\lambda\rho^2} [2\rho(1-\lambda)\tilde{y} - \delta\rho^2\beta_1 + \alpha_0(1-\lambda+2\delta\rho^2\beta_2)]. \quad (\text{B.28})$$

For  $\beta_1$ :

$$\begin{aligned} \beta_1 = & \frac{2(\lambda-1)}{1+\rho} \left( C - \frac{1}{2} + \frac{\alpha_1}{2} - \alpha_1 B \right) \\ & \times \left[ [2A(1-\lambda) - 1]\tilde{y} - A\delta\rho\beta_1 + \alpha_0 \left( \frac{B - \frac{1}{2}}{1+\rho} \right) \right] \\ & - \frac{2\lambda}{1+\rho} \left( \rho C + \frac{1}{2} - \frac{\alpha_1}{2} - \alpha_1 \rho B \right) \\ & \times \left[ 2A(1-\lambda)\rho\tilde{y} - A\delta\rho^2\beta_1 + \alpha_0 \left( \frac{\rho B + \frac{1}{2}}{1+\rho} \right) \right] \\ & - \frac{\delta\beta_1}{1+\rho} \left( \rho C + \frac{1}{2} + \alpha_1(1+\rho) - \alpha_1 \rho B - \frac{\alpha_1}{2} \right) \\ & - \frac{2\delta\beta_2}{1+\rho} \left( \rho C + \frac{1}{2} + \alpha_1(1+\rho) - \alpha_1 \rho B - \frac{\alpha_1}{2} \right) \\ & \times \left[ 2A(1-\lambda)\rho\tilde{y} - A\delta\rho^2\beta_1 + \alpha_0 \left( \frac{\rho B + \frac{1}{2}}{1+\rho} - 1 \right) \right]. \end{aligned}$$

After making some simplifications, following similar steps as before,

$$\beta_1 = \frac{2(1-\lambda)\lambda}{1-\lambda+2\lambda\rho^2} \left( -\rho\tilde{y} - \frac{\alpha_0}{2} \right). \quad (\text{B.29})$$



As to obtain the reduced form for  $\alpha_0$  and  $\beta_1$ , we resort to *Mathematica*:

$$\alpha_0 = \frac{(-1 + \lambda)(-1 + \lambda - 3\lambda\rho^2)(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)\tilde{y}}{\lambda\rho(1 - \lambda + 2\lambda\rho^2)(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)}, \quad (\text{B.30})$$

and

$$\beta_1 = \frac{2(-1 + \lambda)\lambda\rho\tilde{y}}{1 - \lambda + 2\lambda\rho^2} + \frac{(1 - \lambda)^2(-1 + \lambda - 3\lambda\rho^2)(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)\tilde{y}}{\rho(1 - \lambda + 2\lambda\rho^2)^2(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)}. \quad (\text{B.31})$$

## B.2.2 Looking for the steady state

### B.2.2.1 The equilibrium inflation rate

In the steady state, it must be satisfied that  $x_t = x_{t-1} + \bar{k}$ ,  $p_t = p_{t-1} + \bar{k}$  and  $z_{t-1} = z_t$ , where  $\bar{k}$  represents the inflationary bias associated with the steady state.

Hence, making use of Equations (5.13) and (5.14), one can write

$$z_t = p_t - x_t = p_t - \alpha_0 - \alpha_1 z_{t-1} - p_{t-1}. \quad (\text{B.32})$$

Therefore, substituting out Equation (5.23) and simplifying,

$$z_t = 2A\rho(1 - \lambda)\tilde{y} - A\delta\rho^2\beta_1 + \frac{\alpha_0}{1 + \rho}(\rho B - \frac{1}{2} - \rho). \quad (\text{B.33})$$

The reduced form for the state variable is obtained, once again, with resort to *Mathematica*:

$$z_t = \frac{(-1 + \lambda)\tilde{y}(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)}{2\lambda\rho[1 - \lambda + 2\lambda\rho^2 + (\lambda - 1)\delta]}. \quad (\text{B.34})$$

On the other hand, given that Equation (5.7) implies that, in the steady state,

$$x_t = \frac{p_t + p_t + k}{2}, \quad (\text{B.35})$$

one can write

$$z_t = -\frac{k}{2}, \quad (\text{B.36})$$

which leads to

$$\bar{k} = \frac{(1 - \lambda)\tilde{y}(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)}{\lambda\rho[1 - \lambda + 2\lambda\rho^2 + (\lambda - 1)\delta]}. \quad (\text{B.37})$$

### B.2.2.2 The equilibrium level of output

With regard to the expression for output, one needs to substitute the steady state value of  $z_t$ , as given in Equation (B.33), into Equation (5.24), which yields,

$$y_t = \frac{1 - \lambda + 3\lambda\rho^2}{1 - \lambda + 4\lambda\rho^2} [2A(1 - \lambda)\tilde{y} - A\delta\rho\beta_1] + \frac{\alpha_0}{1 + \rho} \left( B - \frac{1}{2} - \frac{\lambda\rho^2 B}{1 - \lambda + 4\lambda\rho^2} - \frac{\lambda\rho}{2(1 - \lambda + 4\lambda\rho^2)} \right).$$

Substituting out the expressions for  $\alpha_0$  and B, one can get

$$\begin{aligned}
y_t = & \frac{A(1 - \lambda + 3\lambda\rho^2)}{1 - \lambda + 4\lambda\rho^2} [2(1 - \lambda)\tilde{y} - \delta\rho\beta_1] \\
& + \left[ \frac{-1 + \lambda - 4\lambda\rho^2 - \lambda\rho + 2A(1 - \lambda + 3\lambda\rho^2)(\beta_2\delta\rho + 2\beta_2\delta\rho^2 + 1 - \lambda - \lambda\rho)}{(1 + \rho)(1 - \lambda + 4\lambda\rho^2)} \right] \\
& \times \left[ \frac{1 - \lambda + 4\lambda\rho^2}{1 - \lambda + 4\lambda\rho^2 - 2A(1 - \lambda + 3\lambda\rho^2)(1 - \lambda + 2\beta_2\delta\rho^2)} \right] \\
& \times \left[ \frac{A(1 - \lambda + 3\lambda\rho^2)}{1 - \lambda + 4\lambda\rho^2} [2\rho(1 - \lambda)\tilde{y} - \delta\rho^2\beta_1] \right].
\end{aligned}$$

Given that,

$$\begin{aligned}
& \rho [-1 + \lambda - 4\lambda\rho^2 - \lambda\rho + 2A(1 - \lambda + 3\lambda\rho^2)(\beta_2\delta\rho + 2\beta_2\delta\rho^2 + 1 - \lambda - \lambda\rho)] = \\
& - (1 + \rho) [1 - \lambda + 4\lambda\rho^2 - 2A(1 - \lambda + 3\lambda\rho^2)(1 - \lambda + 2\beta_2\delta\rho^2)],
\end{aligned}$$

$$y_t = 0. \quad (\text{B.38})$$

### B.2.3 The response of the equilibrium inflation rate to changes in the structural parameters

The derivatives of the steady state inflationary bias with respect to  $\lambda$ ,  $\tilde{y}$ ,  $\rho$  y  $\delta$  can be calculated by resorting to computing techniques.

Hence,

$$D[\bar{k}, \lambda] = \frac{-[(1 - \delta)(1 - \lambda)^2 + 4\lambda\rho^2(1 - \lambda) + 4\lambda^2\rho^4 + 2\delta\lambda^2\rho^4] \tilde{y}}{\lambda^2\rho(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)^2} \leq 0, \quad (\text{B.39})$$



$$D[\bar{k}, \tilde{y}] = \frac{(1 - \lambda)(1 - \lambda + 2\lambda\rho^2 + \delta\lambda\rho^2)}{\lambda\rho(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)} \geq 0, \quad (\text{B.40})$$

$$\begin{aligned} D[\bar{k}, \rho] &= \frac{(1 - \lambda)\tilde{y}}{\lambda\rho^2(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)^2} \\ &\times [(1 - \lambda)^2(-1 + \delta) - 4\lambda\rho^2(1 - \lambda) - \delta\rho^2\lambda(1 + \delta)(1 - \lambda) - 2\lambda^2\rho^4(2 + \delta)] \leq 0, \end{aligned}$$

and

$$D[\bar{k}, \delta] = \frac{(1 - \lambda)\tilde{y}[(1 - \lambda)^2 + 3\lambda\rho^2(1 - \lambda) + 2\lambda^2\rho^4]}{\lambda\rho(1 - \delta - \lambda + \delta\lambda + 2\lambda\rho^2)} \geq 0. \quad (\text{B.41})$$

## B.3 Precommitment to $m_t$

### B.3.1 Solving for the equilibrium

Here we present the *Mathematica* programme designed to obtain the FOC to our problem — Equations (5.25) - (5.28) —, and the set of expressions (5.29) - (5.32).

(\*The model is composed of the following equations below\*) (\*Here 1 appended means t-1 and o is objective loss function\*)

$$y_t := (1 + \rho)^{-1} (m_t - (x_t + x_{t1})/2);$$

$$p_t := (1 + \rho)^{-1} (\rho m_t + (x_t + x_{t1})/2);$$

$$o := (1 - \lambda) (y_t - y_s)^2 + \lambda (p_t - p_{t1})^2 + \delta \beta_0 + \delta \beta_1 z_t + \delta \beta_2 z_t^2;$$

$$z_t := p_t - x_t;$$

$$x_t := \alpha_0 + \alpha_1 z_{t1} + \alpha_2 (m_t - x_{t1}) + p_{t1};$$

(\*Solving for the optimal money supply rule, the F. O. C. implies\*)

$$\text{money} = \text{Solve}[D[o, m_t] == 0, m_t] \gg m_t;$$

(\*Yet, we are interested in a policy rule of the following form:  $\gamma_0 + \gamma_1 z_{t1} + p_{t1}$ . Therefore, we calculate:\*)

$$\text{MONEY} = \text{money} /. x_{t1} \rightarrow p_{t1} - z_{t1} \gg \text{MONEY};$$

```
gamma22 = D[MONEY, pt1] >> gamma22;
```

```
gamma2 = Simplify[gamma22] >> gamma2;
```

(\*As expected, gamma2 is equal to one\*)

```
gamma1 = D[MONEY, zt1] >> gamma1;
```

```
gamma0 = MONEY /. pt1 -> 0, zt1 -> 0 >> gamma0;
```

```
MT = gamma0 + gamma1 zt1 + pt1 >> MT;
```

(\*From here onwards, we rewrite the expressions for output, inflation, the wage contract and the state variable as a function of zt1 only\*)

(\*yt must be equal to an expression of the form  $y_t = \psi_0 + \psi_1 z_{t1}$ \*)

```
output = yt /. xt -> alpha0 + alpha1 zt1 + alpha2 (mt - xt1) + pt1 >> output;
```

```
output1 = output /. xt1 -> pt1 - zt1 >> output1;
```

```
output2 = output1 /. mt -> MT >> output2;
```

```
null = D[output2, pt1];
```

```
null0 = Simplify>null >> null0;
```

(\*This derivative equals zero. Homogeneity properties are, therefore, satisfied.\*)

```
psi11 = D[output2, zt1] >> psi11;
```

```
psi1 = Simplify[psi11] >> psi1;
```



```
psi0 = output2 /. zt1 -> 0, pt1 -> 0 >> psi0;
```

```
OUTPUTt = psi0 + psi1 zt1 >> OUTPUTt;
```

```
(*With respect to prices*)
```

```
price = pt /. xt -> alpha0 + alpha1 zt1 + alpha2 (mt - xt1) + pt1 >> price;
```

```
price0 = price /. xt1 -> pt1 - zt1 >> price0;
```

```
price00 = price0 /. mt -> MT >> price00;
```

```
theta22 = D[price00, pt1] >> theta22;
```

```
theta2 = Simplify[theta22] >> theta2;
```

```
(*As we expected, theta2 is equal to one*)
```

```
theta1 = D[price00, zt1] >> theta1;
```

```
theta0 = price00 /. zt1 -> 0, pt1 -> 0 >> theta0;
```

```
PRICEt = theta0 + theta1 zt1 + pt1 >> PRICEt;
```

```
INFLATIONt = PRICEt - pt1 >> INFLATIONt;
```

```
(*With respect to the contract*)
```

```
contract = xt /. mt -> MT, xt1 -> pt1 - zt1 >> contract;
```

```
alp0 = contract /. zt1 -> 0, pt1 -> 0 >> alp0;
```

```
alp1 = D[contract, zt1] >> alp1;
```

---

$\text{CONTRACT}_t = \text{alp0} + \text{alp1} \text{ zt1} + \text{pt1} \gg \text{CONTRACT}_t;$

(\*With respect to the state variable\*)

$\text{statvar} = \text{PRICE}_t - \text{CONTRACT}_t \gg \text{statvar};$

$\text{pmu0} = \text{statvar} /. \text{zt1} \rightarrow 0, \text{pt1} \rightarrow 0 \gg \text{mu0};$

$\text{mu1} = \text{D}[\text{statvar}, \text{zt1}] \gg \text{mu1};$

$\text{STATVAR}_t = \text{mu0} + \text{mu1} \text{ zt1} \gg \text{STATVAR}_t;$

### B.3.2 Solving for $\alpha_0'$ , $\alpha_1'$ , $\alpha_2'$ , $\beta_1'$ and $\beta_2'$

Under commitment, our consistency conditions lead to the following relationships:

$$\alpha_2' = \frac{2\rho}{1+2\rho}; \tag{B.42}$$

$$\alpha_1' = -1, \tag{B.43}$$

$$\alpha_0' = \frac{(1-\lambda)(1+\rho)\tilde{y}}{2\lambda\rho(1+2\rho)}, \tag{B.44}$$

$$\beta_1' = \frac{(-1+\lambda)(1-\lambda+8\lambda\rho^2)\tilde{y}}{2\rho(1-\lambda+4\lambda\rho^2)}, \tag{B.45}$$

$$\beta_2' = \frac{\lambda(1-\lambda)}{1-\lambda+4\lambda\rho^2}. \tag{B.46}$$



# Appendix C

## Appendix to Chapter 6

### C.1 How to obtain Equation (6.13)

Setting the derivative of the profit function with respect to  $p^m$  equal to zero, given  $w^m = w^*$  and  $\bar{p}$ , one can write

$$\frac{\partial \Pi}{\partial p^m} = (1 - \eta)M \frac{p^{m-\eta}}{\bar{p}^{1-\eta}} + \frac{\eta}{\alpha} \frac{w^*}{e(w^*)} \bar{p}^{1+\frac{\eta-1}{\alpha}} M^{\frac{1}{\alpha}} p^{m-1-\frac{\eta}{\alpha}} = 0. \quad (\text{C.1})$$

Hence,

$$\frac{(\eta - 1)M^{\frac{\alpha-1}{\alpha}} e(w^*)\alpha}{w^*\eta} \bar{p}^{\eta-2+\frac{1-\eta}{\alpha}} = p^{m-1+\eta-\frac{\eta}{\alpha}}. \quad (\text{C.2})$$

Then, given that  $\bar{p} = p^{m^{1-\beta}} p^{nm^\beta}$  and making use of

$$k^* = \left[ \frac{1}{\eta-1} \frac{\eta}{\alpha} \frac{w^*}{e(w^*)} \right]^{\alpha/(1-\alpha)}, \quad (\text{C.3})$$

it follows

$$(k^* M)^{\frac{\alpha-1}{\alpha}} p_0^{\beta(\eta-2+\frac{1-\eta}{\alpha})} = p^{m^{\frac{-\eta}{\alpha}-1+\eta+(\beta-1)(\eta-2+\frac{1-\eta}{\alpha})}}. \quad (\text{C.4})$$

If  $M = M_0(1 + \epsilon)$  and  $k^* M_0 = p_0$ ,

$$p_0^{\frac{\alpha-1}{\alpha} + \beta(\eta-2+\frac{1-\eta}{\alpha})} (1 + \epsilon)^{\frac{\alpha-1}{\alpha}} = p^{m^{\frac{-\eta}{\alpha}-1+\eta+(\beta-1)(\eta-2+\frac{1-\eta}{\alpha})}}. \quad (\text{C.5})$$

Note that

$$\frac{-\eta}{\alpha} - 1 + \eta + (\beta-1)(\eta-2+\frac{1-\eta}{\alpha}) = 1 + \beta\eta - 2\beta + \frac{\beta}{\alpha} - \frac{\beta\eta}{\alpha} - \frac{1}{\alpha}, \quad (\text{C.6})$$

and

$$\frac{\alpha-1}{\alpha} + \beta(\eta-2+\frac{1-\eta}{\alpha}) = 1 + \beta\eta - 2\beta + \frac{\beta}{\alpha} - \frac{\beta\eta}{\alpha} - \frac{1}{\alpha}.$$

Therefore, one can simplify this expression to look like

$$p^m = p_0(1 + \epsilon)^\theta, \quad (\text{C.7})$$

where

$$\theta = \frac{(1-\alpha)/\alpha}{\beta(\eta/\alpha - \eta + 1) + (1-\beta)(1-\alpha)/\alpha} \leq 1. \quad (\text{C.8})$$

## C.2 How to obtain Equation (6.18)

First, we define the average level of employment as the following geometric mean,

$$\bar{N} = N_{nm}^\beta N_m^{1-\beta}. \quad (\text{C.9})$$

Given the production function in Equation (6.2), one can write

$$\bar{N} = \left[ \frac{Y_{nm}^{1/\alpha}}{e(w_{nm})} \right]^\beta \left[ \frac{Y_m^{1/\alpha}}{e(w_m)} \right]^{1-\beta}. \quad (\text{C.10})$$

From the demand curve for each type of firm, Equation (6.1), it follows that, in the short run,

$$\begin{aligned} \bar{N} = & \left[ \frac{1}{e(w^*(1+\epsilon)^{-(1-\beta)\theta})} \right]^\beta \left[ \left[ \frac{p_0}{p_0(1+\epsilon)^{(1-\beta)\theta}} \right]^{-\eta} \frac{M_0(1+\epsilon)}{p_0(1+\epsilon)^{(1-\beta)\theta}} \right]^{\beta/\alpha} \\ & \times \left[ \frac{1}{e(w^*)} \right]^{1-\beta} \left[ \left[ \frac{p_0(1+\epsilon)^\theta}{p_0(1+\epsilon)^{(1-\beta)\theta}} \right]^{-\eta} \frac{M_0(1+\epsilon)}{p_0(1+\epsilon)^{(1-\beta)\theta}} \right]^{(1-\beta)/\alpha}. \end{aligned}$$



Or

$$\begin{aligned}\bar{N} &= \left[ \frac{M_0(1+\epsilon)}{p_0(1+\epsilon)^{(1-\beta)\theta}} \right]^{1/\alpha} \frac{1}{e(w^*)^{1-\beta} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta} \\ &= \frac{k^{*-1/\alpha}}{e(w^*)^{1-\beta} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta} (1+\epsilon)^{(1+\beta\theta-\theta)/\alpha}.\end{aligned}$$

Thus, given the firm's long run labour demand,

$$N_0 = \frac{k^{*-1/\alpha}}{e(w^*)}, \quad (\text{C.11})$$

the non-neutrality of money implies that the elasticity of employment with respect to changes in the money supply is not zero. This elasticity can be calculated as,

$$\begin{aligned}\frac{\partial (\bar{N}/N_0)}{\partial \epsilon} &= \frac{(1+\beta\theta-\theta)e(w^*)(1+\epsilon)^{[(1+\beta\theta-\theta)/\alpha]-1}}{\alpha e(w^*)^{2(1-\beta)} e(w^*(1+\epsilon)^{-(1-\beta)\theta})^{2\beta}} e(w^*)^{1-\beta} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^\beta \\ &\quad - \frac{e(w^*)(1+\epsilon)^{(1+\beta\theta-\theta)/\alpha}}{e(w^*)^{2(1-\beta)} \cdot e(w^*(1+\epsilon)^{-(1-\beta)\theta})^{2\beta}} e(w^*)^{1-\beta} \beta e(w^*(1+\epsilon)^{-(1-\beta)\theta})^{\beta-1} \frac{\partial e(\tilde{w})}{\partial \tilde{w}} \frac{\partial \tilde{w}}{\partial \epsilon},\end{aligned}$$

where  $\tilde{w} = w^*(1+\epsilon)^{-(1-\beta)\theta}$ , so that  $\frac{\partial \tilde{w}}{\partial \epsilon} = -(1-\beta)\theta w^*(1+\epsilon)^{-(1-\beta)\theta-1}$ .

Applying the envelope theorem<sup>1</sup>, we evaluate the differential at  $\epsilon = 0$ , where  $w^* = \tilde{w}$ . Then, making use of

$$\frac{\partial e(w^*)}{\partial w^*} \frac{w^*}{e(w^*)} = 1,$$

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<sup>1</sup>See Varian (1979).

one obtains

$$\left. \frac{\partial (\bar{N}/N_0)}{\partial \epsilon} \right|_{\epsilon=0} = \frac{1 + \beta\theta - \theta}{\alpha} + \beta(1 - \beta)\theta \geq 0. \quad (\text{C.12})$$